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DRAFT SITE CHARACTERIZATION PLAN
FOR THE 116-B-6-1 CRIB
ISV DEMONSTRATION PROJECT

S. S. Koegler
S. J. Mitchell
K. B. Olsen
S. S. Teel

March 1989

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this site characterization plan is to provide guidance to Pacific Northwest Laboratory (PNL) and its site characterization contractors for drilling and sampling the 116-B-6-1 crib prior to a demonstration test of the in situ vitrification (ISV) process at the site. This plan contains a short description of the ISV technology, a summary of the information known about the crib, the geology/hydrology of the surrounding area, and a description of the work to be performed in characterizing the crib prior to performing the ISV demonstration test.

Because the ISV test is a technology demonstration test to be performed under Section 6 of OSWER Directive 9335.3-01 (EPA's guidance for RI/FS treatability tests under CERCLA), site characterization will be limited to those activities necessary to successfully implement and evaluate the ISV test and to provide assurance of minimal impact of the test on the environment. The ISV test is a technology demonstration and not a remedial action. This technology demonstration is undertaken as part of the development of a treatability study work plan (see Figure 1). Full characterization of the crib soils, ground water, and surrounding site is beyond the scope of the project and will be completed as part of the formal Remedial Investigation/Feasibility Study (RI/FS) process for the 100-BC-1 Operable Unit at a later date. However, efforts will be made to obtain the site characterization data for this treatability test in such a way as to make it suitable for inclusion in later studies.

1.2 CHARACTERIZATION NEEDS

The characterization needs include tasks necessary for determining the ISV test operating parameters, those necessary for environmental surveillance, and obtaining those site characterization data which will be more difficult to acquire after the test is completed. To complete the treatability study work plan for the ISV test, the site characterization must provide the concentrations and locations of the principal contaminants in and below the crib and determine whether other priority pollutants are present (see section 4.0 Sampling and Analysis Plan). In addition, the geology of the soil beneath the crib will be determined because of its impact on the ISV process operation. Other site characterization tasks, including installation of a ground-water monitoring well, will help assess the crib area before and after the ISV test. Minimal environmental impact is expected by a combination of

site characterization and extrapolation from the large data base of previous ISV experience (Buelt et al. 1987).

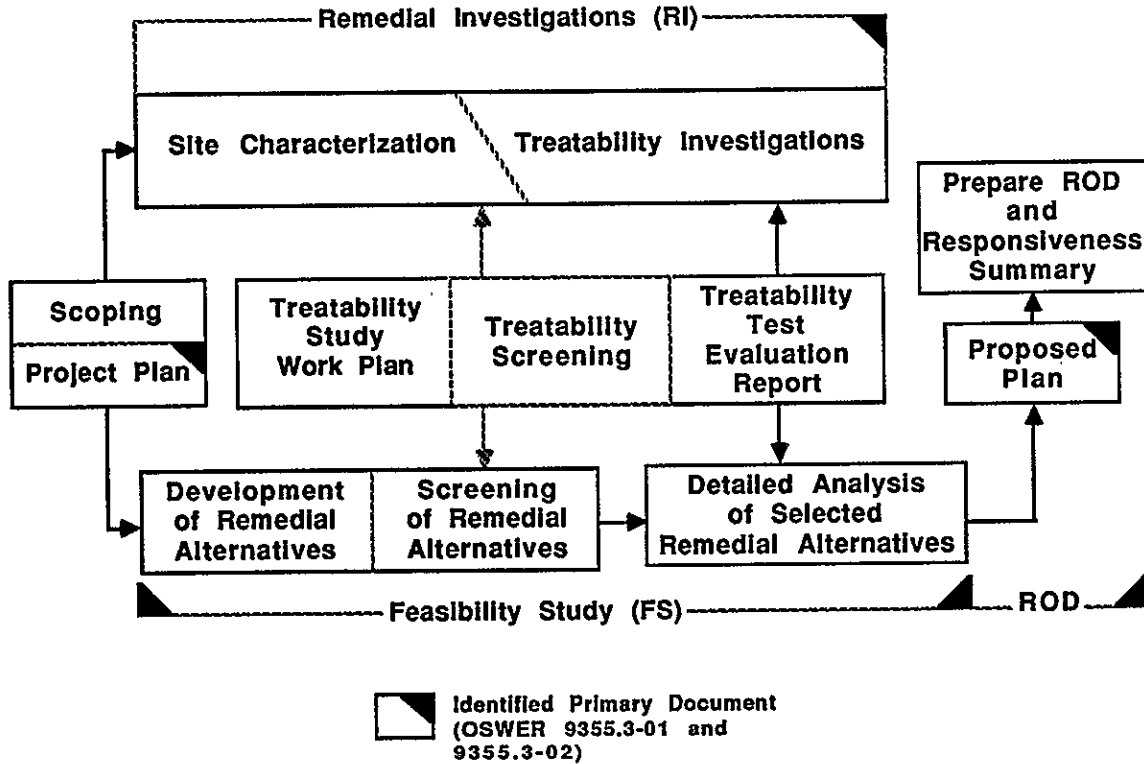


FIGURE 1. Information Flow in the RI/FS/ROD Process

2.0 BACKGROUND

2.1 ISV PROCESS DESCRIPTION

In situ vitrification is a process developed by the Pacific Northwest Laboratory (PNL) to provide enhanced environmental stability to contaminated soils without exhumation. The technology for ISV of buried waste is based upon electric melter technology developed at PNL to immobilize high-level nuclear waste. In situ vitrification was initially tested by researchers in 1980 (Brouns, Buelt, and Bonner 1983). Since then ISV has been developed through a series of engineering-scale (laboratory), pilot-scale (small-scale field), and large-scale tests (Buelt et al. 1987).

Figure 2 depicts the process. A square array of four molybdenum and graphite electrodes is inserted into the ground to the desired treatment depth. Because soil is not electrically conductive when the moisture has been

driven off, a graphite-containing starter material is placed on the surface of the soil between the electrodes to form a conductive starter path. An electric current is passed between the electrodes to establish an electric current in the starter path. The resultant power heats the starter path, creating temperatures high enough to melt the soil (typically about 1700°C). The starter path is consumed by oxidation, and the current is transferred to the molten soil, which is electrically conductive. As the molten zone grows downward and outward (past the electrodes), it encompasses the contaminated soil and incorporates the radionuclides and nonvolatile hazardous elements, such as heavy metals, and destroys organic components by pyrolysis. The pyrolyzed by-products migrate to the surface of the vitrified zone, where they burn in the presence of air. A hood, placed over the area being vitrified, directs the gaseous effluents to an off-gas treatment system.

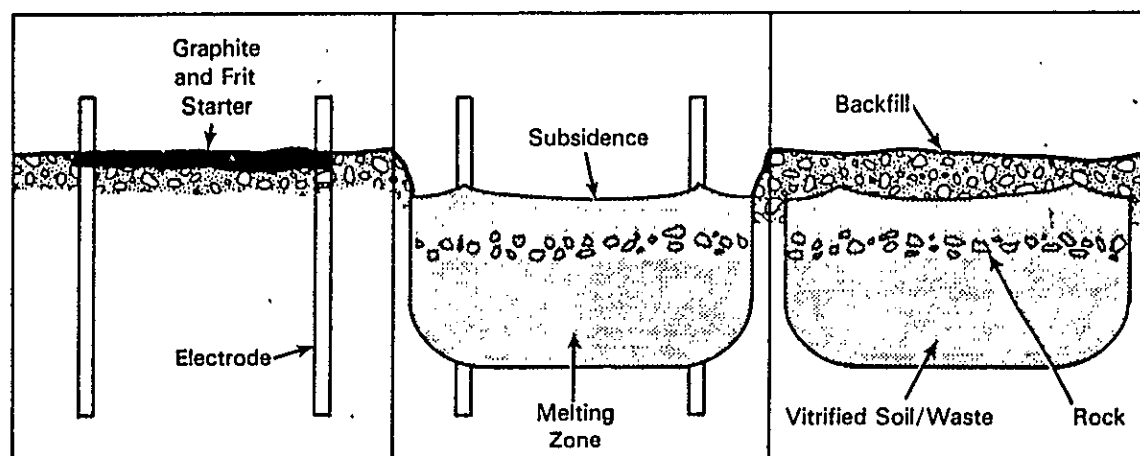


FIGURE 2. In Situ Vitrification Process

Upon cooling, the product of ISV is a vitreous mass of relatively high strength and chemical integrity resembling natural obsidian. The ISV block is extremely inert, with a chemical leach resistance approaching that of Pyrex glass (Oma, Farnsworth, and Rusin 1982).

2.2 SITE DESCRIPTION AND HISTORY

General Description of the Hanford Site

The Hanford Site is a 560-square mile tract of semiarid land that is owned and operated by the U.S. Department of Energy. This site is located northwest of the city of Richland, Washington, in the Columbia Basin (Figure 3). In early 1943, the U.S. Army Corps of Engineers selected the Hanford Site as the

location for reactor, chemical separation, and related facilities and activities for the production and purification of plutonium. A total of eight graphite-moderated reactors using Columbia River water for once-through cooling were built along the Columbia River. These reactors were operated from 1944 to 1971.

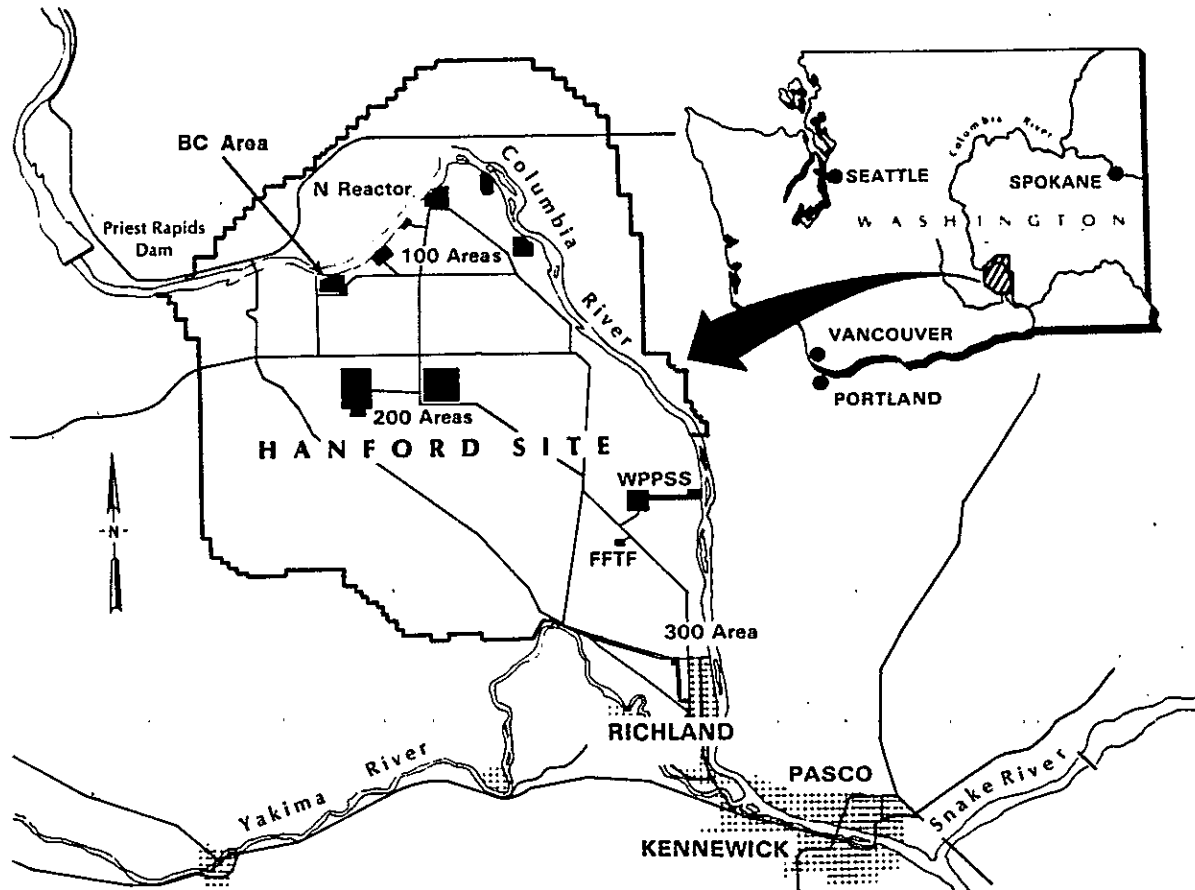


FIGURE 3. Map of the Hanford Reservation

Reactor facilities (active and decommissioned) are located along the Columbia River in what are known as the 100 Areas. The reactor fuel processing and waste management facilities are in the 200 Areas, which are on a plateau about seven miles from the river. The 300 Area, located north of Richland, contains the reactor fuel manufacturing facilities and the research and development laboratories. The 400 Area, five miles northwest of the 300 Area, contains the Fast Flux Test Facility (FFTF). The 1100 Area, north of Richland, contains facilities associated with maintenance and transportation

functions for the Hanford Site. Administrative buildings and other research and development laboratories are found in the 3000 Area, also located north of Richland.

116-B-6-1 Crib Description

The 116-B Crib, located in the 100-B Area of the Hanford Site (Figure 4), is an inactive mixed waste site that historically received liquid radioactive wastes from the decontamination of equipment and fuel element spacers performed at the 111-B Building. The waste site was operated from 1951 through 1968, when it was retired.

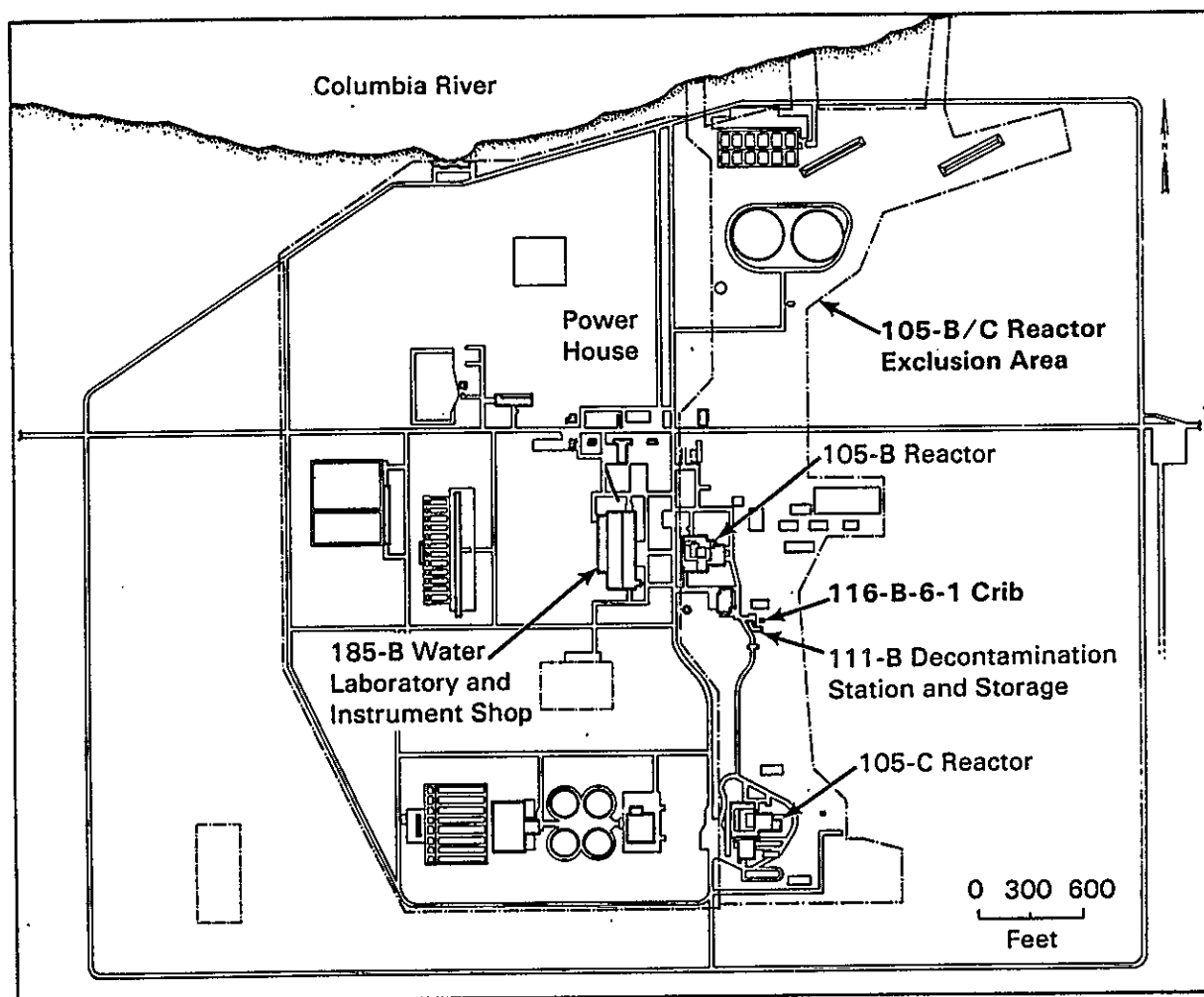


FIGURE 4. 100-B and 100-C Reactor Areas

The crib is located at Hanford coordinates 68620 north by 80335 west. The site is in a semiarid location with 6.3 in./yr average precipitation. Figure 5 shows the crib location as determined by ground-penetrating radar (GPR) in relation to the site marker and the 111-B foundation and pad.

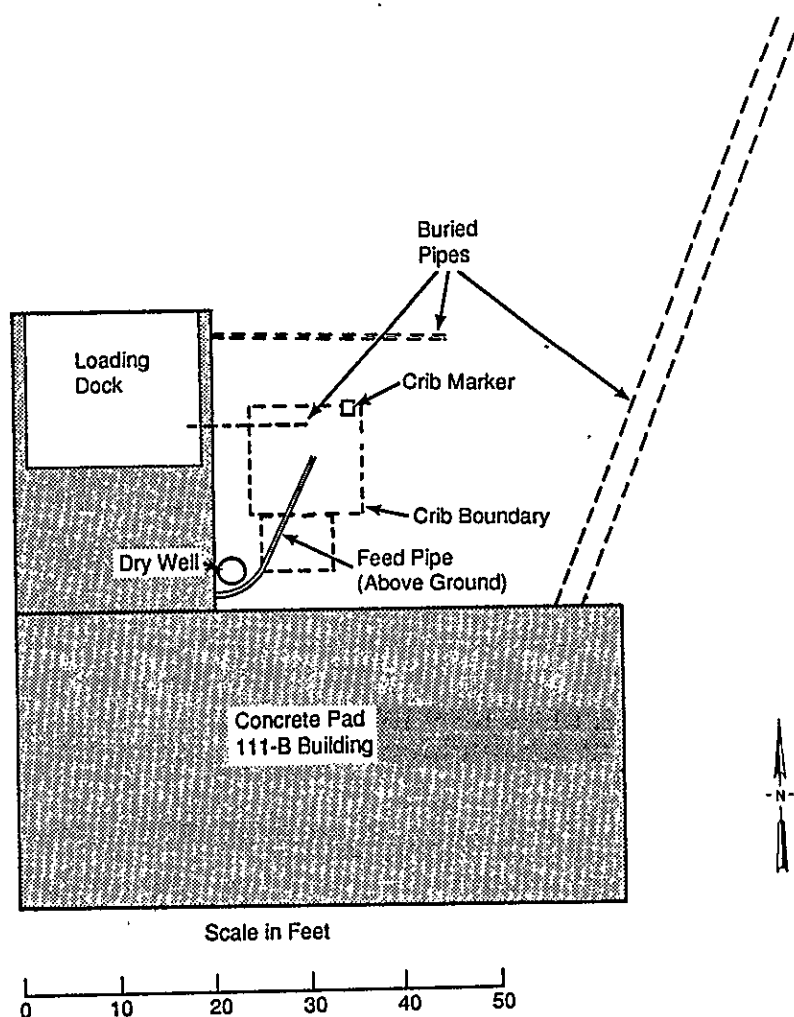


FIGURE 5. 116-B-6-1 Crib in Relation to the Site Marker and the 111-B Foundation and Pad

A crib is defined as "an earth-covered structure for liquid disposal, with box(es), horizontal pipe, or uniform gravel to provide distribution and surge space" (Clukey 1956). Initial investigations found conflicting information on the 116-B Crib geometry and detailed drawings could not be located. In a 1954 document on radioactive liquid waste disposal facilities

(Clukey 1954), the structure was described as 12 ft square by 8 ft high, buried 6 ft underground. The surface elevation was reported as 474 ft and the bottom elevation as 460 ft (a difference of 14 ft), which agrees with the 8-ft crib height plus 6-ft burial depth. Because of the lack of detailed characterization information, a preliminary site survey using ground-penetrating radar was performed to verify the crib boundaries, size, and materials of construction. The GPR survey confirmed the crib dimensions and depth and showed the crib marker to be on the north-east corner of the crib. The crib appears to be constructed of wooden timbers with rocky backfill, as shown in Figure 6.

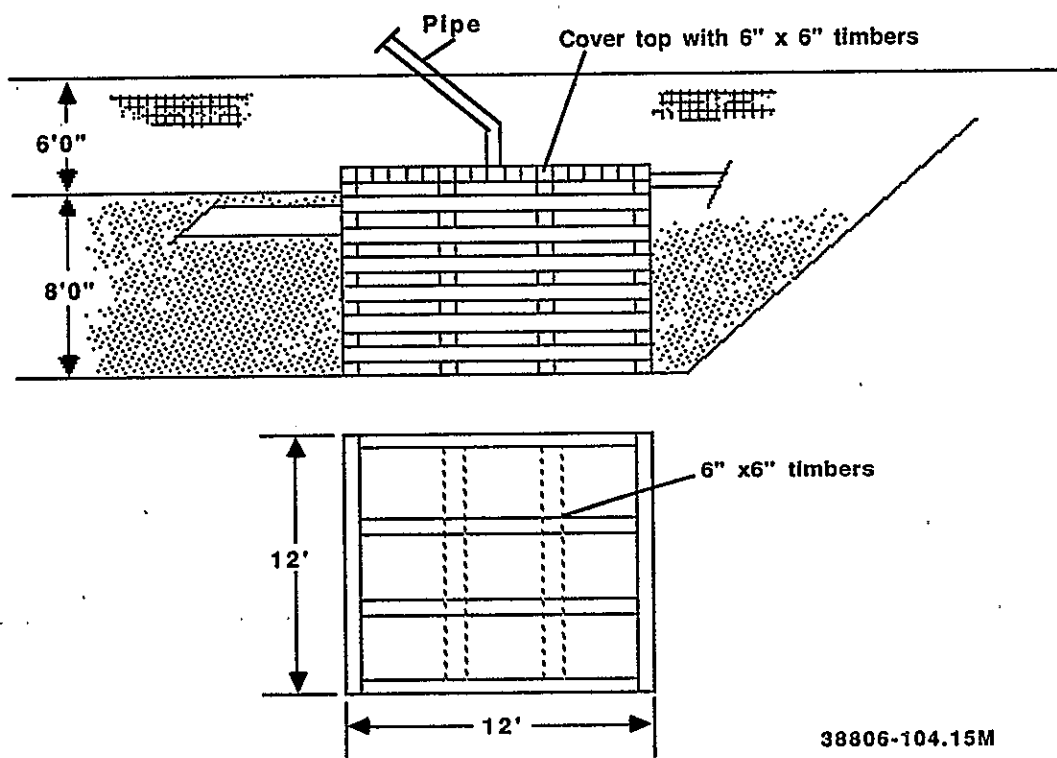


FIGURE 6. Representative Timber Crib Structure

The 116-B Crib may simply contain gravel since no wood was reported in a drill log from the site in 1976 that penetrated the crib. However, GPR determined a definite lid, indicative of a wooden crib structure. The drill log revealed that the crib contents were mostly cobbles and pebbles of various sizes (20% large cobbles, 20% small cobbles, 20% large pebbles, 20% small pebbles, 10% sand, and 10% silt).

A total of 5000 L of chemical wastes were disposed of in the crib. The principal chemicals disposed are sodium dichromate, sodium oxalate, and sodium

sulfamate. The chemicals disposed and the radionuclide inventory are presented in Table 1, based on historical records.

TABLE 1. 116-B-6-1 Crib Waste Inventory

Chemicals Inventory:

Sodium Dichromate ($\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$)	50 kg
Sodium Oxalate ($\text{Na}_2\text{C}_2\text{O}_4$)	100 kg
Sodium Sulfamate (NaNH_2SO_3)	100 kg

Radionuclide Inventory (decayed through 04/01/86):

^{90}Sr	0.9000 Ci
^{137}Cs	0.1490 Ci
^{155}Eu	0.0023 Ci
^{60}Co	0.0022 Ci
^{239}Pu	0.0018 Ci
^{238}U	0.0009 Ci
^{240}Pu	0.0002 Ci
^{152}Eu	0.0001 Ci
^{154}Eu	<u>0.0001 Ci</u>
Total -	1.06 Ci

TABLE 2. Drill Log Data and Radionuclide Analysis (1976)

Depth ft	Count c/m	Radionuclides, pCi/g							
		^{90}Sr	^{137}Cs	^{155}Eu	^{60}Co	$^{239/240}\text{Pu}$	^{238}U	^{152}Eu	^{154}Eu
0	<100	-(a)	-	-	-	-	-	-	-
5	<100	-	-	-	-	-	-	-	-
10	<100	-	-	-	-	-	-	-	-
15	1000	1400	210	15	6.1	3.6	1.0	0.29	0.41
17.5	800	-	-	-	-	-	-	-	-
20	600	2200	370	8.6	15	3.0	-	-	0.18
22.5	200	34	21	0.87	0.78	0.19	-	-	0.27
25	30	-	-	-	-	-	-	-	-

(a) Samples with (-) were not analyzed.

A drill hole was drilled into the site in 1976 about 2 ft south of the crib marker, and sample results are presented in Table 2. Essentially, no radioactivity was detected in samples less than 15 ft deep. This supports the fact that the bottom of the crib is reportedly 14 ft below the surface because

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activity is typically concentrated in the soil below the crib. Radionuclides were found from 15 ft to 22.5 ft, while the activity at 25 ft was at background levels. The wastes are present in the solid form in the soil surrounding the crib. The primary hazardous waste of concern is the chromium content of the site. An estimated 17.5 kg of chromium is present as part of the sodium dichromate.

2.3 EXISTING WELLS

There are eight existing ground-water monitoring wells in the 100-B Area: 199-B3-1; 199-B3-2P,Q; 199-B-4-1; 199-B4-2; 199-B4-3; 199-B4-4; 199-B5-1; and 199-B9-1. All of these wells, except well 199-B3-2P,Q, monitor the upper portion of the unconfined aquifer. Well 199-B3-2 is composed of piezometers "P" and "Q" which monitor the base of the unconfined aquifer (Q) and the upper confined aquifer (P). The locations of these wells is shown in Figure 7. The monitoring intervals of these wells are shown in Table 3.

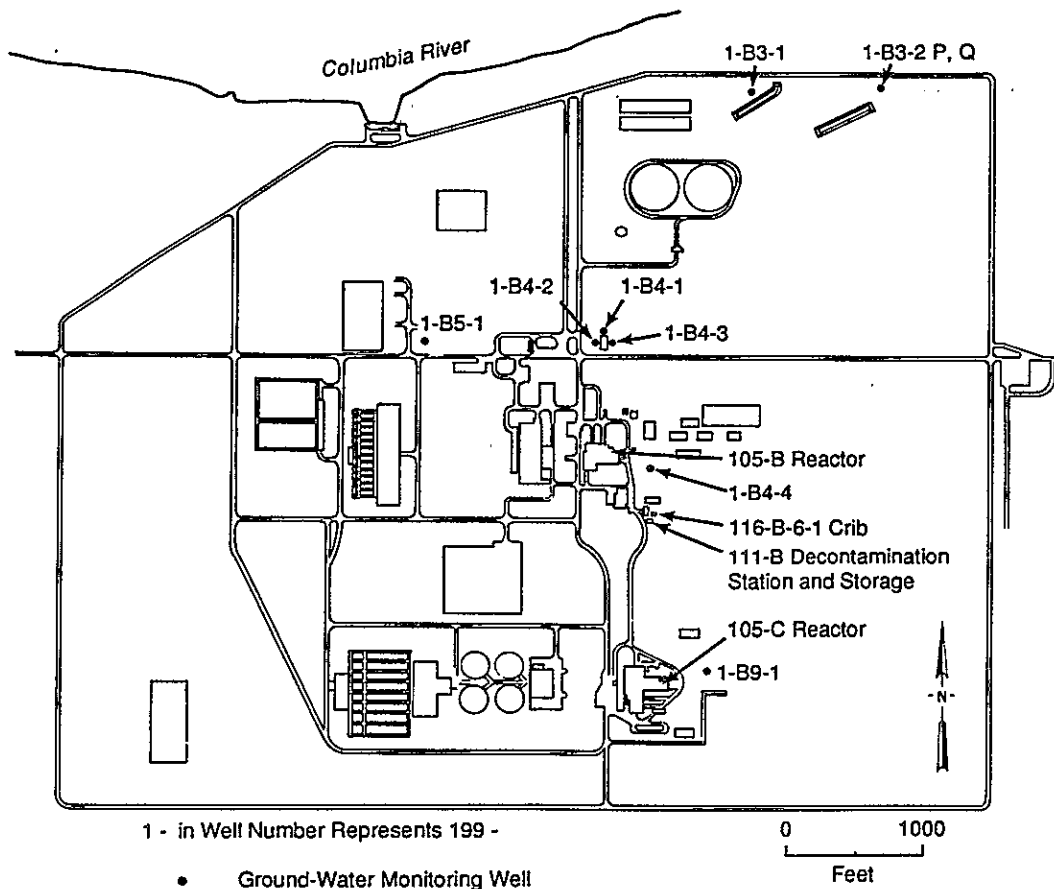


FIGURE 7. Locations of Existing Wells in the 100-B Area

TABLE 3. Monitoring Intervals of Existing Wells, ft

<u>Well No.</u>	<u>Monitoring Interval</u>	<u>Approx. Depth to Water</u>	<u>Feet of Aquifer Penetrated</u>	<u>Date Drilled</u>
199-B3-1	20-60	44	19	3/53
199-B3-2P	758-778	39	739	8/53
199-B3-2Q	632-642	34	608	8/53
199-B4-1	50-90	63	27	2/49
199-B4-2	62-86	63	27	2/49
199-B4-3	60-86	63	27	2/49
199-B4-4	49-102	74	28	9/60
199-B5-1	40-100	57	43	8/62
199-B9-1	80-110	97	13	7/52

The wells are all constructed with 8-in carbon steel casing (except for well 199-B4-2 which is constructed with 6-in casing). Perforations in the casing allow water to enter the well from the aquifer. The 1.5-in screened piezometer pipes were later installed in well 199-B3-2. Only one well, 199-B3-2, penetrates deeper than 151 ft. This well was drilled to a depth of 790 ft and encountered basalt at a depth of 656 ft.

The nearest existing well to the 116-B-6-1 crib is well 199-B4-4, which is approximately 350 ft away. Wells 199-B9-1 and 199-B4-3 are approximately 1200 and 1250 ft away, respectively, from the crib.

2.4 SITE GEOLOGY

The site geology consists of three distinct geologic units: the Columbia River Basalt Group, the Ringold Formation, and the Hanford formation. Well 199-B3-2 is the only well within the 100-B Area which encountered basalt; all other wells were drilled to depths between 63 ft and 151 ft. Geologic cross sections for the area shown in Figure 8 are given in Figures 9 and 10. Well construction/lithologic diagrams for the existing wells are shown in Appendix A.

The Columbia River Basalt Group forms the bedrock beneath 100-B Area. It was encountered at 656 ft below ground surface in well 199-B3-2. Overlying the basalt are the sediments of the Ringold Formation. The Hanford formation unconformably overlies the Ringold Formation. An unconformity is an erosional surface which separates strata of different ages. Detailed textural and lithologic information would be necessary to accurately distinguish the contact between these formations. This information does not exist, and therefore the location of this contact in the 100-B area is unknown.

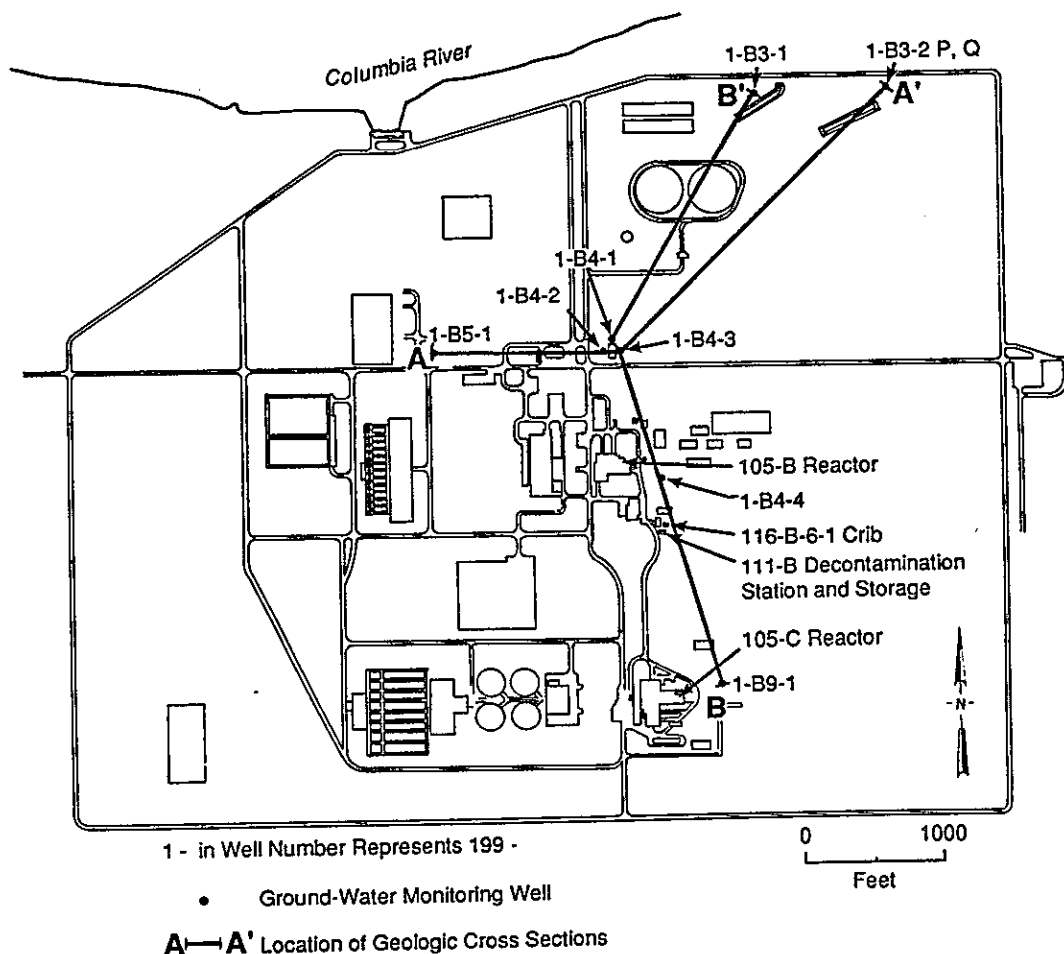


FIGURE 8. Locations of Geologic Cross Sections A-A' and B-B'

Textures as described on the drillers' logs and shown on the cross sections consist of: sandy gravel and silty sandy gravel mixed with cobbles and boulders from 0-25 ft; silty sandy gravel/sandy gravel with some sand layers from 25-300 ft; alternating layers of sandy gravel, silt/clay, and sand to approximately 385 ft; clay from 390-425 ft; alternating layers of sand and clay (or sandy clay) to 480 ft; clay from 485-590 ft; silty sandy gravel/sandy gravel with some sand and silt/clay layers to 648; and blue clay from 648 to the top of the Columbia River basalt at 656 ft (see ground-water monitoring well lithology, Appendix A).

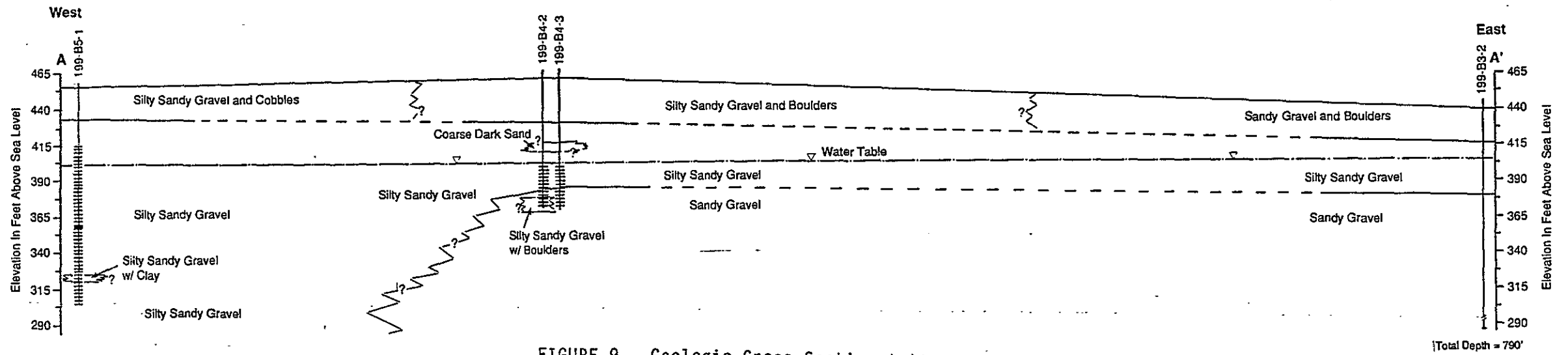


FIGURE 9. Geologic Cross Section A-A'

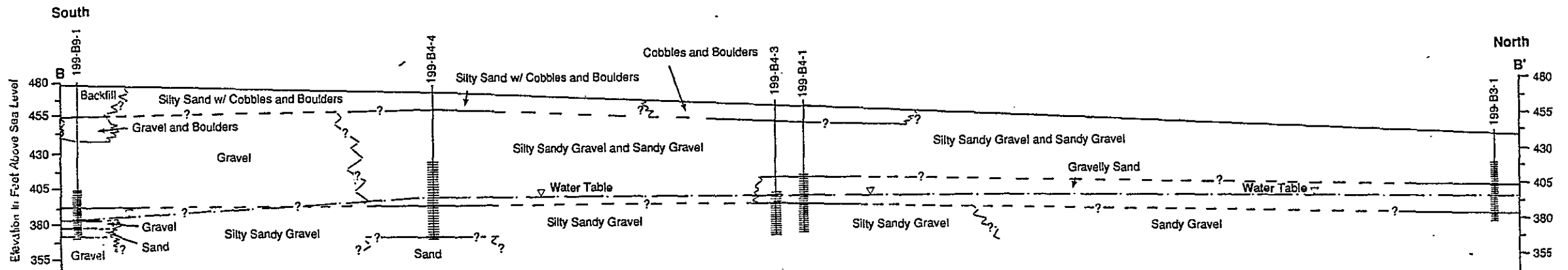


FIGURE 10. Geologic Cross Section B-B'

Scale in Feet

0 100 200 300 400

Vertical Exaggeration = 4X

Legend

Well (w/ Perforations)

Water Table (January 1989)

Facies Contact

Approximate Facies Contact

Well 199-B9-1 was originally located in a pit that was approximately 25 ft deep. A 24.5-ft section of 8-in carbon steel casing was added to the upper portion of the well in May 1974, and the pit was backfilled. The characteristics of the backfill material are undocumented, but visual observations indicate that the material consists of the sandy gravel and cobble mixture present elsewhere in the 100-B Area. The casing elevation was originally surveyed in 1967. There is no evidence that the well was resurveyed after the casing was added. This may explain why water level data from this well are consistently 10 to 12 ft below local water table trends (see Figure 10).

2.5 SITE HYDROLOGY

The unconfined aquifer in the 100-B Area is contained in the sands and gravels of the Ringold Formation/Hanford formation. The depth to the water table in the 100-B Area ranges from approximately 41 to 93 ft below land surface. The elevation of the water table ranges from approximately 395 to 401 ft above mean sea level. A water table map of the 100-B Area and surrounding 600 Area was constructed using data collected on February 7, 1989, and is shown in Figure 11. Due to uncertainty in the casing elevation of well 199-B9-1 (see previous section), this well was omitted from Figure 11.

The precise direction of ground-water flow beneath the 116-B-6-1 crib is unknown. Figure 11 suggests that it is predominantly northward. However, the extent of influence that changes in river stage have on the water table beneath the 100-B Area is not known. Pressure transducers, which measure changes in water level, have been installed in wells 199-B3-1 (the 100-B Area well closest to the river) and 199-B4-4 (the well closest to the crib). Data from these transducers will help determine the degree of influence that changes in river stage have upon the elevation of water table beneath the 116-B-6-1 crib. Further hydrology will be done as part of the 100-BC-1 RI/FS.

2.6 WATER CHEMISTRY DATA

Table 4 summarizes the water chemistry data in the 100-B Area for the past 5 years. As the table indicates (by the symbol ***), most contaminants were found to be below detection limits. However, six constituents (as shown by the symbol xxx), exceeded standards in samples taken during this time period. The National Interim Primary Drinking Water Regulations (40 CFR 141, July, 1987 as amended by 52 FR 25690) standards for these constituents were gross beta, 50 pCi/L; strontium-90, 8 pCi/L; tritium, 20,000 pCi/L; chromium, 50 ppb; nitrate, 45,000 ppb ; and coliform bacteria, 1 MPN (most probable number).

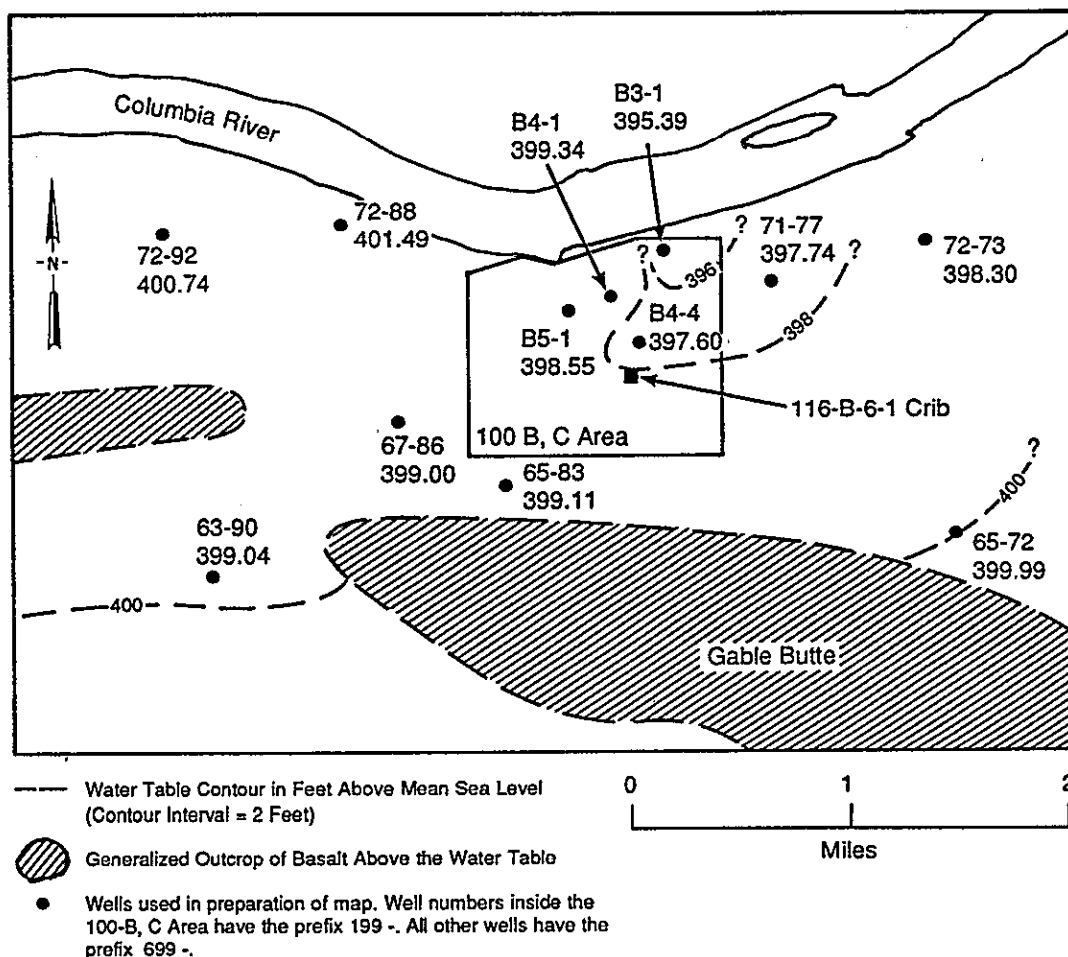


FIGURE 11. Water Table Map of the 100-B Area Measured on February 7, 1989

- Gross beta values above the standard occurred in wells 199-B3-1, 199-B3-2, 199-B4-1, 199-B4-2, 199-B4-3, and 199-B4-4. (See Figure 7.) The maximum concentration observed was 179 pCi/L in well 199-B3-1 (4/4/88).
- Strontium-90 values above the standard occurred in wells 199-B3-1, 199-B4-1, 199-B4-2, 199-B4-3, and 199-B4-4. The maximum concentration observed was 57.5 pCi/L in well 199-B3-1 (4/4/88). Values for well 199-B4-4 ranged from 31.0 (7/30/87) to 35.4 (10/19/87).

TABLE 4. Summary of Ground-Water Samples Taken 1-Jan-84
to 31-Dec-88 in the 100-B Area

----- Constituent List=Primary Drinking Water Standards -----

Constituent Name	Units	Detection Limit	Samples	Below Detection	Drinking Water Standard	Agency	Exceeded	Full name
TRITIUM	pCi/L	500	118	0	20000	EPA	xxx	Tritium (H-3)
COLIFRM	MPN	3	2	1	1	EPA	xxx	Coliform bacteria
BETA	pCi/L	8	29	0	50	EPA	xxx	Gross beta
NITRATE	mg/L	0.5	4	0	45	EPA		Nitrate (phenoldisulfonic acid method)
NO3-ION	mg/L	0.5	55	0	45	EPA	xxx	Nitrate (ion specific electrode)
SR-90	pCi/L	5	18	0	8	EPA	xxx	Strontium-90
RADIUM	pCi/L	1	8	0	5	EPA		Total radium
ALPHA	pCi/L	4	17	0	15	EPA		Gross alpha
BARIUM	ppb	8	2	0	1000	EPA		Barium
CADMIUM	ppb	2	2	1	10	EPA		Cadmium
CHROMIUM	ppb	10	2	0	50	EPA		Chromium
SILVER	ppb	10	2	2	50	EPA		Silver
ARSENIC	ppb	5	2	2	50	EPA		Arsenic
MERCURY	ppb	0.1	2	2	2	EPA		Mercury
SELENIUM	ppb	5	2	2	10	EPA		Selenium
ENDRIN	ppb	1	2	2	0.2	EPA		Endrin
METHLOR	ppb	1	2	2	100	EPA		Methoxychlor
TOXAENE	ppb	1	2	2	5	EPA		Toxaphene
a-BHC	ppb	1	2	2	4	EPA		Lindane, alpha-BHC
b-BHC	ppb	1	2	2	4	EPA		Lindane, beta-BHC
g-BHC	ppb	1	2	2	4	EPA		Lindane, gamma-BHC
d-BHC	ppb	1	2	2	4	EPA		Lindane, delta-BHC
TETRANE	ppb	10	13	13	5	EPA		Tetrachloromethane [Carbon Tetrachloride]
BENZENE	ppb	10	8	8	5	EPA		Benzene
1,1,1-T	ppb	10	13	13	200	EPA		1,1,1-Trichloroethane
TRICENE	ppb	10	13	12	5	EPA		Trichloroethylene [1,1,2-Trichloroethene]
CHLFORM	ppb	10	13	13	100	EPA		Chloroform [Trichloromethane]
1,2-DIC	ppb	10	8	8	5	EPA		1,2-Dichloroethane
DICETHY	ppb	10	8	8	7	EPA		1,1-Dichloroethylene
BROMORM	ppb	10	8	8	100	EPA		Bromoform [Tribromomethane]
VINYIDE	ppb	10	8	8	2	EPA		Vinyl chloride
NITRATE	ppb	500	40	0	45000	EPA	xxx	Nitrate
FLUORID	ppb	500	15	15	4000	EPA		Fluoride
2,4-D	ppb	1	2	2	100	EPA		2,4-D [2,4-Dichlorophenoxyacetic acid]
2,4,5TP	ppb	1	2	2	10	EPA		2,4,5-TP silvex
FBARIUM	ppb	8	13	0	1000	EPA		Barium, filtered
FCADMIU	ppb	2	13	11	10	EPA		Cadmium, filtered
FCHROMI	ppb	10	13	0	50	EPA	xxx	Chromium, filtered
FSILVER	ppb	10	13	13	50	EPA		Silver, filtered
FARSENI	ppb	5	13	13	50	EPA		Arsenic, filtered
FMERCUR	ppb	0.1	13	13	2	EPA		Mercury, filtered
FSELENI	ppb	5	13	13	10	EPA		Selenium, filtered
FLEAD	ppb	5	13	13	50	EPA		Lead, filtered
LFLUORD	ppb	20	6	0	4000	EPA		Fluoride, low DL
HNITRAT	ppb	2500	26	2	45000	EPA	xxx	Nitrate, high DL

TABLE 4 (Con't). Summary of Ground-Water Samples Taken 1-Jan-84
to 31-Dec-88 in the 100-B Area

----- Constituent List=Contamination Indicators -----

Constituent Name	Units	Detection Limit	Samples	Below Detection	Drinking Water Standards Standard Agency Exceeded	Full name
CONDFLD	umho	1	14	0	700 WDOE	Specific conductance, field
PHFIELD		0.1	13	0	8.5 EPAS	pH, field
PH-LAB		0.01	13	0	8.5 EPAS	pH, laboratory
TOX	ppb	100	2	0	.	Total organic halogen
TOC	ppb	1000	15	0	.	Total organic carbon
TOXLDL	ppb	20	13	7	.	Total organic halogens, low DL

----- Constituent List=Quality Characteristics -----

Constituent Name	Units	Detection Limit	Samples	Below Detection	Drinking Water Standards Standard Agency Exceeded	Full name
SODIUM	ppb	200	2	0	.	Sodium
MANGESE	ppb	5	2	1	50 EPAS	Manganese
IRON	ppb	50	2	1	300 EPAS	Iron
PHENOL	ppb	10	8	8 ***	.	Phenol
SULFATE	ppb	500	15	0	250000 EPAS	Sulfate
CHLORID	ppb	500	15	0	250000 EPAS	Chloride
FSODIUM	ppb	200	13	0	.	Sodium, filtered
FMANGAN	ppb	5	13	9	50 EPAS	Manganese, filtered
FIRON	ppb	50	13	12	300 EPAS	Iron, filtered

----- Constituent List=Other Constituents -----

Constituent Name	Units	Detection Limit	Samples	Below Detection	Drinking Water Standards Standard Agency Exceeded	Full name
CO-60	pCi/L	22.5	44	0	100 EPAR	Cobalt-60
CS-137	pCi/L	20	37	0	200 EPAR	Cesium-137
RU-106	pCi/L	172.5	37	0	30 EPAR	Ruthenium-106
U	pCi/L	0.5	12	0	600 DOE	Uranium
TC-99	pCi/L	15	9	0	900 EPAR	Technetium-99
LEAD	ppb	30	2	2 ***	.	Lead (discontinued ICP, use A51-LEADGF)
NICKEL	ppb	10	2	2 ***	.	Nickel
COPPER	ppb	10	2	2 ***	1300 EPAP	Copper
VANADIUM	ppb	5	2	1	.	Vanadium
ANTIMONY	ppb	100	2	2 ***	.	Antimony
ALUMINUM	ppb	150	2	2 ***	.	Aluminum
POTASSIUM	ppb	100	2	0	.	Potassium
DIOXANE	ppb	500	6	6 ***	.	Dioxane
METHONE	ppb	10	13	13 ***	.	Methyl ethyl ketone
PYRIDINE	ppb	500	6	6 ***	.	Pyridine
TOLUENE	ppb	10	6	6 ***	2000 EPAP	Toluene
1,1,2-T	ppb	10	13	13 ***	.	1,1,2-Trichloroethane
PERCENE	ppb	10	13	13 ***	.	Perchloroethylene [Tetrachloroethene]
OPXYLE	ppb	10	13	13 ***	440 EPAP	Xylene-o,p
ACROLIN	ppb	10	6	6 ***	.	Acrolein
ACRYILE	ppb	10	6	6 ***	.	Acrylonitrile
BISTHER	ppb	10	6	6 ***	.	Bis(chloromethyl) ether

TABLE 4 (Con't). Summary of Ground-Water Samples Taken 1-Jan-84
to 31-Dec-88 in the 100-B Area

----- Constituent List=Other Constituents -----						
Constituent Name	Units	Detection Limit	Samples	Below Detection	Drinking Water Standards Standard Agency Exceeded	Full name
BROMONE	ppb	10	6	6 ***	.	Bromoacetone
METHBRO	ppb	10	6	6 ***	.	Methyl bromide
CARBIDE	ppb	10	6	6 ***	.	Carbon disulfide
CHLBENZ	ppb	10	6	6 ***	60 EPAP	Chlorobenzene
CHLTHER	ppb	10	6	6 ***	.	2-Chloroethyl vinyl ether
METHCHL	ppb	10	6	6 ***	.	Methyl chloride [Chloromethane]
CHMTHER	ppb	10	6	6 ***	.	Chloromethyl methyl ether
CROTONA	ppb	10	6	6 ***	.	Crotonaldehyde
DIBRCHL	ppb	10	6	6 ***	0 EPAP	1,2-Dibromo-3-chloropropane
DIBRETH	ppb	10	6	6 ***	.	1,2-Dibromoethane
DIBRMET	ppb	10	6	6 ***	.	Dibromomethane
DIBUTEN	ppb	10	6	6 ***	.	1,4-Dichloro-2-butene
DICDIFM	ppb	10	6	6 ***	.	Dichlorodifluoromethane
1,1-DIC	ppb	10	6	6 ***	.	1,1-Dichloroethane
TRANDE	ppb	10	6	6 ***	70 EPAP	trans-1,2-Dichloroethene
METHYCH	ppb	10	13	13 ***	.	Methylene chloride [Dichloromethane]
DICPANE	ppb	10	6	6 ***	6 EPAP	1,2-Dichloropropane
DICPENE	ppb	10	6	6 ***	.	1,3-Dichloropropane
NNDIEHY	ppb	10	6	6 ***	.	N,N-diethylhydrazine
1,1-DIM	ppb	3000	4	4 ***	.	1,1-Dimethylhydrazine
1,2-DIM	ppb	3000	4	4 ***	.	1,2-Dimethylhydrazine
HYDRSUL	ppb	10	6	6 ***	.	Hydrogen sulfide
IODOMET	ppb	10	6	6 ***	.	Iodomethane
METHACR	ppb	10	6	6 ***	.	Methacrylonitrile
METHTHI	ppb	10	6	6 ***	.	Methanethiol
PENTACH	ppb	10	6	6 ***	.	Pentachloroethane
1112-tc	ppb	10	6	6 ***	.	1,1,1,2-Tetrachloroethane
1122-tc	ppb	10	6	6 ***	.	1,1,2,2-Tetrachloroethane
TRCMEOL	ppb	10	6	6 ***	.	Trichloromethanethiol
TRCMFLM	ppb	10	6	6 ***	.	Trichloromonofluoromethane
TRCPANE	ppb	10	6	6 ***	.	Trichloropropane
123-trp	ppb	10	6	6 ***	.	1,2,3-Trichloropropane
M-XYLE	ppb	10	13	13 ***	440 EPAP	Xylene-m
DIETHY	ppb	10	6	6 ***	.	Diethylarsine
ACETILE	ppb	3000	7	7 ***	.	Acetonitrile
12-dben	ppb	10	8	8 ***	.	1,2-Dichlorobenzene
13-dben	ppb	10	8	8 ***	.	1,3-Dichlorobenzene
14-dben	ppb	10	8	8 ***	75 PA	1,4-Dichlorobenzene
HEXC BEN	ppb	10	8	8 ***	.	Hexachlorobenzene
METACRY	ppb	10	6	6 ***	.	Methyl methacrylate
PENTCHB	ppb	10	8	8 ***	.	Pentachlorobenzene
TETRCHB	ppb	10	8	8 ***	.	1,2,4,5-Tetrachlorobenzene
TRICHLB	ppb	10	8	8 ***	.	1,2,4-Trichlorobenzene
HYDRAZI	ppb	3000	4	4 ***	.	Hydrazine
HEXACHL	ppb	10	8	8 ***	.	Hexachlorophene
NAPHTHA	ppb	10	8	8 ***	.	Naphthalene
123TRI	ppb	10	8	8 ***	.	1,2,3-Trichlorobenzene
135TRI	ppb	10	8	8 ***	.	1,3,5-Trichlorobenzene
1234TE	ppb	10	8	8 ***	.	1,2,3,4-Tetrachlorobenzene
1235TE	ppb	10	8	8 ***	.	1,2,3,5-Tetrachlorobenzene
CYANIDE	ppb	10	8	8 ***	.	Cyanide
FORMALN	ppb	500	6	6 ***	.	Formalin
PHOSPHA	ppb	1000	15	15 ***	.	Phosphate

TABLE 4 (Con't). Summary of Ground-Water Samples Taken 1-Jan-84 to 31-Dec-88 in the 100-B Area

----- Constituent List=Other Constituents -----						
Constituent Name	Units	Detection Limit	Samples	Below Detection	Drinking Water Standards Standard Agency Exceeded	Full name
KEROSEN	ppb	10000	8	8 ***	.	Kerosene
AMMONIU	ppb	50	13	12	.	Ammonium ion
CYANBRO	ppb	3000	4	4 ***	.	Cyanogen bromide
CYANCHL	ppb	3000	4	4 ***	.	Cyanogen chloride
PARALDE	ppb	3000	4	4 ***	.	Paraldehyde
ACRYIDE	ppb	3000	4	4 ***	0 EPAP	Acrylamide
ALLYLAL	ppb	3000	4	4 ***	.	Allyl alcohol
CHLORAL	ppb	3000	4	4 ***	.	Chloral
CHLACET	ppb	3000	4	4 ***	.	Chloroacetaldehyde
CHLPROP	ppb	3000	4	4 ***	.	3-Chloropropionitrile
CYANOGN	ppb	3000	4	4 ***	.	Cyanogen
DICPROP	ppb	3000	4	4 ***	.	Dichloropropanol
ETHCARB	ppb	3000	4	4 ***	.	Ethyl carbamate
ETHCYAN	ppb	3000	4	4 ***	.	Ethyl cyanide
ETHOXID	ppb	3000	7	7 ***	.	Ethylene oxide
ETHMETH	ppb	10	6	6 ***	.	Ethyl methacrylate
FLUOROA	ppb	3000	4	4 ***	.	Fluoroacetic acid
GLYCIDY	ppb	3000	4	4 ***	.	Glycidylaldehyde
ISOBUTY	ppb	3000	4	4 ***	.	Isobutyl alcohol
METZINE	ppb	3000	4	4 ***	.	Methyl hydrazine
PROPYLA	ppb	3000	4	4 ***	.	n-Propylamine
PROPYNO	ppb	3000	4	4 ***	.	2-Propyn-1-ol
TC	ppb	1000	6	0	.	Total carbon
FZINC	ppb	5	13	7	5000 EPAS	Zinc, filtered
FCALCIU	ppb	50	13	0	.	Calcium, filtered
FNICKEL	ppb	10	13	13 ***	.	Nickel, filtered
FCOPPER	ppb	10	13	13 ***	1300 EPAP	Copper, filtered
FVANADI	ppb	5	13	4	.	Vanadium, filtered
FALUMIN	ppb	150	13	13 ***	.	Aluminum, filtered
FPOTASS	ppb	100	13	0	.	Potassium, filtered
FMAGNES	ppb	50	13	0	.	Magnesium, filtered
FBERYLL	ppb	5	13	13 ***	.	Beryllium, filtered
FOSMIUM	ppb	300	10	10 ***	.	Osmium, filtered
FSTRONT	ppb	300	13	10	.	Strontium, filtered
FANTIMO	ppb	100	13	13 ***	.	Antimony, filtered
ALKALIN	ppb	20000	13	0	.	Total alkalinity, as CaCO3
LHYDRAZ	ppb	30	1	1 ***	.	Hydrazine, low DL
BISMUTH	ppb	5	3	3 ***	.	Bismuth
HEXONE	ppb	10	3	3 ***	.	Hexone
ACETONE	ppb	10	1	0	.	Acetone
TRIBUPH	ppb	10	3	3 ***	.	Tributylphosphoric acid

*** - Indicates all samples were reported as below contractual detection limits

xxx - Indicates that Drinking Water Standards were exceeded

EPA - based on Maximum Contaminant Levels given in 40 CFR Part 141 (July, 1987)
National Primary Drinking Water Regulations as amended by 52 FR 25690EPAR - based on National Interim Primary Drinking Water Regulations,
Appendix IV, EPA-570/9-78-003

EPAP - based on proposed Maximum Contaminant Level Goals in 50 FR 46936

EPAS - based on Secondary Maximum Contaminant Levels given in 40 CFR Part 143
National Secondary Drinking Water RegulationsWDOE - based on additional Secondary Maximum Contaminant Levels given in
WAC 248-54, Public Water Supplies

- Tritium concentrations above the 20,000 pCi/L standard were exceeded in wells 199-B4-1 and 199-B4-3. The maximum concentration observed was 75,500 pCi/L in well 199-B4-1 (1/12/87)
- Chromium (filtered) was above the standard in one sampling event in one well, 199-B3-1 (62 ppb, 5/21/87).
- Nitrate concentrations above the standard occurred in wells 199-B3-1, 199-B4-1, 199-B4-2, and 199-B9-1. The maximum concentration observed was 73,000 ppb in well 199-B3-1 (5/22/84).
- Two of the samples collected were analyzed for coliform bacteria: 199-B4-1 (8/5/85) and 199-B9-1 (9/13/85). At least one of these samples was above the drinking water standard: the values reported were <3 MPN and 4 MPN, respectively. Since the laboratory's contractual limit is 1 MPN, it is not known whether the sample from well 199-B4-1 was above the standard.

No volatile organic constituents were detected at any well, except possibly 199-B4-4, where a value of 2.4 ppb of trichloroethylene (TCE) was reported on 7/30/87. However, the contractual detection limit (CDL) for this constituent was then 10 ppb, and the reported value was less than the CDL. That a result was reported suggests the laboratory had some indication that this constituent was present; but since the value is below the CDL, this cannot be confirmed. The maximum contaminant level for this constituent is 5 ppb (52 FR 25690-717).

3.0 DESCRIPTION OF WORK

3.1 DRILLING

Objectives

Site characterization activities will be conducted prior to the ISV treatability test at the 116-B-6-1 crib in the 100-BC-1 Operable Unit. The objectives of the proposed characterization activities at the 116-B-6-1 crib are to collect data that will: 1) indicate the type, concentration, and vertical and lateral extent of contamination within the zone to be vitrified; 2) provide an indication of ground-water quality in the vicinity of the crib, both before and after in situ vitrification; 3) determine the crib lithology for ISV operations; and 4) provide input for the 100-BC-1 RI/FS.

These objectives will be met through: 1) analyses of soil samples; 2) analyses of ground-water samples; 3) collection and analyses of soil gas

samples; 4) geologic logs taken during drilling; and 5) results of in-situ gamma counting with a downhole intrinsic germanium detector. In addition, soil samples will be collected during installation of the four electrodes which are part of the ISV process equipment. These samples will be archived for possible future analyses.

Proposed Boreholes/Monitoring Well

It is proposed that two boreholes and one ground-water monitoring well be installed to help complete the site characterization objectives. Figure 12 provides a map of the site showing the crib, existing structures, and proposed borehole/well locations. The locations of the crib and the buried pipes are based on the results of ground-penetrating radar work conducted in 1988. Boreholes 1 and 2 will be drilled through the crib to a depth of about 30 ft or to 10 ft past any field-measurable contamination (whichever is greater). Borehole 1 will be located near the center of the crib, between the ends of the feed pipe and the pipe coming from the loading dock. Borehole 2 will be drilled at the south-central edge of the crib.

The ground-water monitoring well will be drilled approximately 30 ft north of the crib and to about 18 ft below the water table. This depth will allow for fluctuations in the water table and will monitor the upper part of the water table, which would be affected first by changes due to the ISV test. The water table is approximately 74 ft at the crib site.

Ground-water Monitoring Rationale

The decision to limit the drilling to three boreholes was based on measurements from earlier ISV tests at other sites. Measurements have been made in several ISV field tests to determine the degree of inorganic contaminant migration into the surrounding soil. In three nonradioactive ISV field tests performed in 1981 and 1982, samples of soil around the vitrified soil were analyzed for the inorganic contaminants vitrified. In these tests, which vitrified 5000 to 20,000 kg of soil, soil samples were taken at three radial positions around the block and directly below the block. At each position, samples were collected directly adjacent to and 1 ft away from the block at depth intervals of 6 in. The samples were analyzed for the chemical contaminants added to the soil for the test (Sr, Cs, La, and Nd). Of all the samples analyzed, only the one directly below the block in the second test showed traces of Sr and Cs.

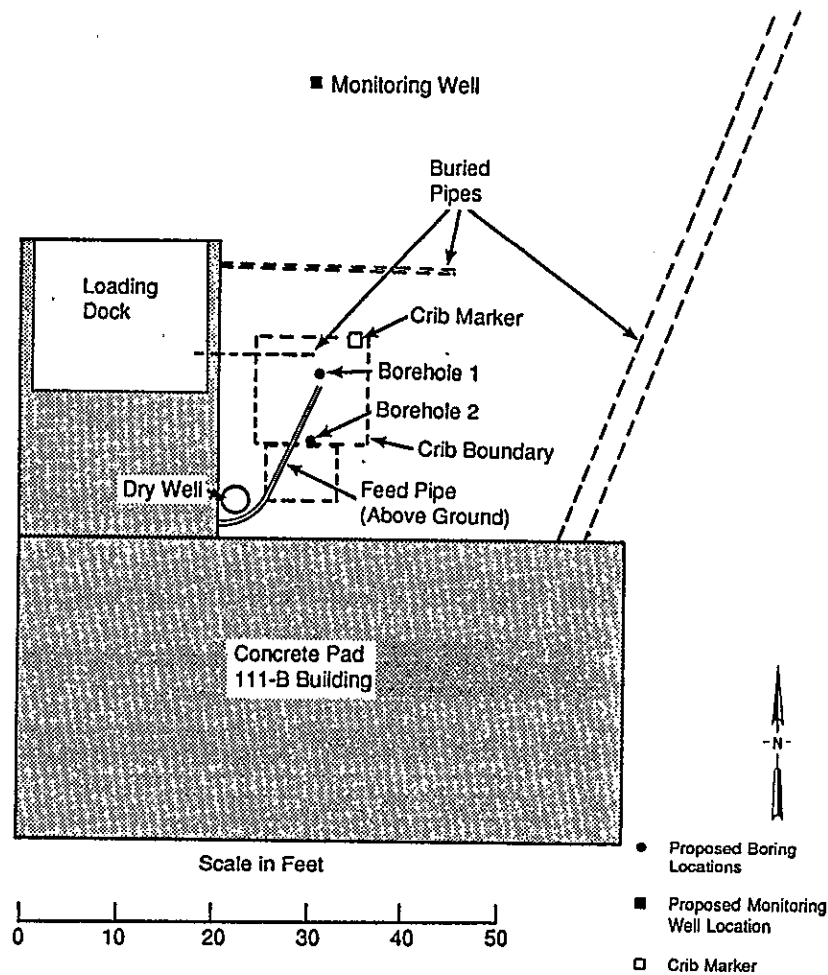


FIGURE 12. Map of the 116-B-6-1 Showing Proposed Boreholes and Wells

No other evidence of migration was found in these tests or the radioactive field test which followed. After a radioactive test in June 1983, soil samples adjacent to the block were taken at depth intervals of 6 in. and analyzed for radionuclides. Only the surface soil samples showed radionuclide concentrations above background levels, due to surface contamination from the off gas (Timmerman and Oma, 1984). No other inorganic contaminant soil migration has been observed. Migration of organic contaminants to the surrounding soil has been detected in vitrification of PCBs and other organics. However, the chemicals were found only close to the vitrified block, within the range at which ISV affects the temperature of the surrounding soil (PNL 1986).

From the results of these and other pilot- and engineering-scale tests performed since, PNL has concluded that migration of inorganics (including metals) into the soil during ISV operation is minimal. Because contamination of the surrounding soil during ISV processing is expected to be low and because the thermal/physical effects of ISV on the soil are limited by the soil's low thermal conductivity to less than 2 ft from the block, the ground water should not be affected and extensive ground-water monitoring will not be required. However, one ground-water well will be drilled to determine the ground-water quality in the vicinity of the crib before and after the vitrification test. The well will be placed outside the vitrification zone and near the crib. Although historical records indicate that no organics were disposed in the crib, PNL will also perform organic chemical analyses on selected soil samples from the vadose zone (as described in the soil analysis section) to ensure that none are present.

Options for Prevention of Subsidence

One safety concern during drilling and sampling activities is the possibility for subsidence or cave-in of the 116-B-6-1 crib site. It is believed that the crib is built of wooden timbers which may have deteriorated over time. Minor subsidence has already occurred at the site, and the wooden structure's integrity is in question. The possibility for subsidence will be alleviated by one of two options: 1) using a bridgework structure to support the drilling equipment or 2) filling the crib with material prior to drilling. In the first option, a bridge structure will be used to support drilling equipment and personnel to avoid placing any load on the top of the crib. In the second option, a slurry of chemicals (glass frit, sodium silicate, and an inorganic suspending agent) would be injected into the rocky backfill beneath the crib and into the crib interior to fill any voids. Filling of the 116-B-6-1 crib is planned prior to ISV operations to promote downward melting. However, use of bridgework is preferred to injection filling for subsidence prevention to avoid any effect the addition of materials may have on the characterization process. Using a bridgework structure will be pursued as the favored option.

Drilling Method

The cable-tool drilling method will be used for both boreholes and the groundwater monitoring well. Cable-tool drilling is desirable because 1) drill cuttings are easily contained (important in contaminated material), 2) representative geologic samples can be collected, 3) samples for moisture and hazardous chemical analyses can be collected above the water table using

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a drive barrel or split spoon sampler, and 4) disturbance to the borehole wall is minimized. To prevent introducing contaminants into the borehole, the drill rigs and peripheral equipment (such as drill tools, cables, and temporary casing) will be steam-cleaned before drilling each well. Water from the cleaning process will be collected and treated/disposed as required.

Temporary carbon steel casing will be used to keep the borehole open and to seal off any contamination that may be encountered during drilling. The minimum inside diameter of the temporary casing in the monitoring well will be 8 in. to allow enough room for the permanent 4-in. 304 stainless steel casing. Boreholes 1 and 2 will be backfilled with bentonite after reaching total depth during removal of the temporary casing. One or both of the boreholes may be used for filling the crib prior to ISV operations.

Spoil or cuttings resulting from drilling operations at boreholes 1 and 2 will be contained. The results of the laboratory analyses will be used to determine the appropriate disposal method. Spoil or cuttings resulting from drilling operations at the monitoring well will be contained if field-measurable contamination is encountered in order to prevent contaminating the site's surface soils.

At the monitoring well, ground-water samples will be taken for analysis as soon as the water table is reached. Analyses will include: metals, gross alpha, gross beta, gamma scan, tritium, and nitrate. Water and well cuttings will be contained and held until their radioactive and hazardous constituent contents are determined. Water and well cuttings will not be discharged to the ground surface unless the analytical results are below acceptable limits (WHC 1988).

Monitoring Well Design

After the final depth is reached, the permanent stainless steel casing will be set. The stainless steel casing will be 4-in.-dia, type 304 stainless steel, flush-threaded with Viton O-rings. The screen will be made of continuous-wire-wrap stainless steel, and will be 20 ft long. The screen will be placed so that approximately 2 ft extends above the water table. Its appropriate slot size will be determined by the site geologist.

Once the permanent casing has been set in the monitoring well, backpulling of the temporary carbon steel casing will begin as the annular seal material is added. At least 2 ft of overlap must be kept inside the temporary casing both to maintain borehole integrity and to ensure adequate placement of the filter pack and seal. The filter pack will consist of Colorado silica sand of the appropriate mesh size for the stainless steel screen. The filter pack

will be placed in the annulus from total well depth to a minimum of 5 ft above the top of the screen. A bentonite pellet seal at least 5 ft thick will then be placed on top of the sand pack. The annulus area above the bentonite pellet seal, and up to a maximum of 21 ft below ground surface, will be filled with bentonite crumbles or granules. Cement grout mixed with 5% bentonite will then be installed to 3 ft below ground surface. A 4-ft by 4-ft by 4-in. concrete pad with 1.5-in. maximum size aggregate and steel reinforcement, will be poured around the permanent casing. A brass survey marker will be set in the concrete to record the well name. Guardposts will be installed at each corner of the pad to protect the well head. A schematic diagram of a completed well is shown in Figure 13.

After completion, the monitoring well will be surveyed for location and elevation by a licensed surveyor. The elevation of the brass marker and the top of the stainless steel casing will be determined to the nearest 0.02 ft. with a mark placed on each to indicate the location that was surveyed. The aerial location will be determined to the nearest 0.5 ft. All measurements will be referenced to a common datum (preferably a Hanford Site datum).

Well Development

After completion of well 3, and before any ground-water samples can be taken, the well must be developed. Any combination of surge-and-bail, overpumping, or any other appropriate method may be used until the water is below 5 NTU (nephelometric turbidity units) as measured by a turbidity meter, and contains less than 8 mg/L of sediment. PNL technical procedure AT-4, Well Development, contained in Procedures for Ground-water Investigations (PNL, 1989), should be followed. Development water will be contained and held until radioactive and hazardous constituent content is determined. Water will not be discharged to the ground surface unless the analytical results are below acceptable limits.

Ground-water Sampling

Ground-water samples may be collected after the well is properly developed. One sample will be taken both before and after the ISV test for analysis. Details of the ground-water sampling task are presented in Section 4.0.

3.2 SOIL SAMPLE COLLECTION

Sediment samples will be collected for analysis of texture, moisture, pH, radionuclides, and hazardous chemicals. During the drilling of boreholes 1

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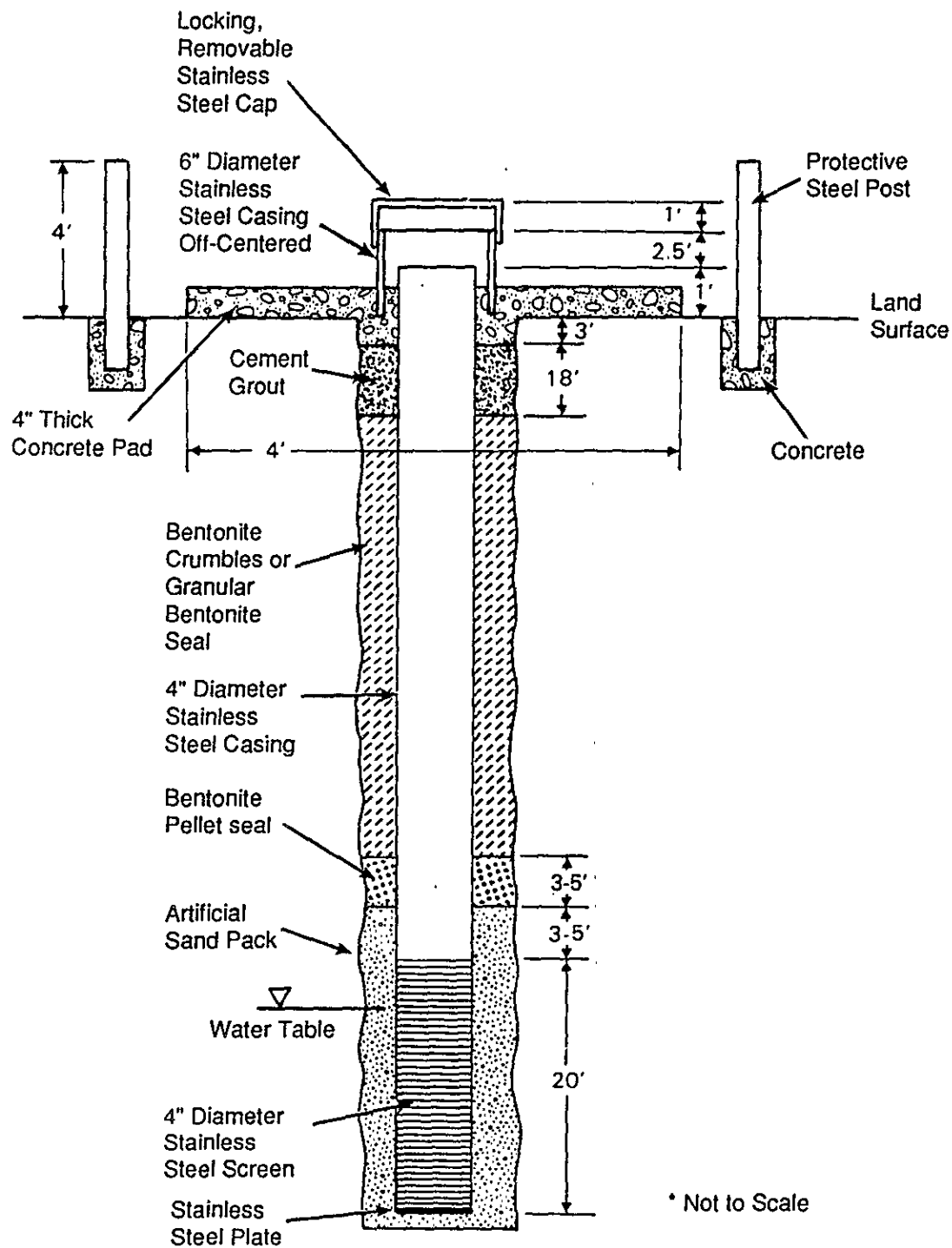


Figure 13. Schematic Diagram of Completed Well

and 2, archive samples will be collected at least every foot. At the monitoring well, samples will be collected at 5-ft intervals. Selected samples from from the two boreholes and the monitoring well will be analyzed for percent moisture. Analyses for hazardous chemicals will be conducted at 2-ft intervals in boreholes 1 and 2, beginning with the 6-ft sample, and on selected samples collected from the monitoring well below 14 ft. Soil pH will be measured in the field on each sample collected for chemical analysis. Table 5 summarizes the sampling and analyses intervals. The site geologist will describe each sample in a geologic log. The Sampling and Analysis Plan, in section 4.0, discusses the sampling and analysis tasks in detail.

TABLE 5. Sampling and Analysis Intervals

<u>Sampling Interval</u>	<u>Archive Samples</u>	<u>Hazardous Chemical Samples</u>
Boreholes 1 and 2	1 ft minimum	Every 2 ft, starting at 6 ft
Electrode holes	2 ft	Archive only
Monitoring Well	5 ft	Every 5 ft, starting at 14 ft
<u>Field Analysis</u>	<u>Archive Samples</u>	<u>Hazardous Chemical Samples</u>
Boreholes 1 and 2 and ground-water monitoring well	Organics (relative), using photoionizer; alpha and gamma energy using portable units	pH
<u>Laboratory Analysis</u>	<u>Archive Samples</u>	<u>Hazardous Chemical Samples</u>
Boreholes 1 and 2 and ground-water monitoring well	none	Metals, EP toxicity, anions, cations, TOC, VOAs, oxalate, sulfamate, Appendix IX list, gamma, moisture (on selected samples)

4.0 SAMPLING AND ANALYSIS PLAN

4.1 INTRODUCTION

This section documents the ground-water and soil sampling and analysis activities planned for characterization of the 116-B-6-1 Crib ISV demonstration site. It is divided into two sections: 1) ground-water sampling and 2) soil sampling.

4.2 GROUND-WATER SAMPLING

Included in this section are the procedures and methods for sample collection (including methods to purge the monitoring well and withdraw

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ground-water samples), field measurements, sample preservation and shipment, chemical analysis, chain of custody, and quality control. All sampling activities are currently performed by Pacific Northwest Laboratory (PNL). United States Testing Company, Incorporated (UST), currently conducts sample analyses for most constituents. Ground-water samples will be collected and analyzed before and after the ISV demonstration test to assess the ground-water quality in the general area of the 116-B-6-1 Crib.

Sample Collection Procedures

The procedures for ground-water sample collection, water-level measurements, and field measurements are contained in Procedures for Ground-Water Investigations (PNL 1989). Constituents to be analyzed, analytical methods, and detection limits for the ground-water samples are shown in Appendix B, Tables B.1 and B.2. Specific applicable procedures are as follows:

- GC-1 - Ground-Water Sample Collection Procedure
- GC-2 - In-Line Sample Filtration Procedure
- GC-3 - Disposal of Purge Water from Monitoring Wells
- FA-1 - Temperature Measurement Procedure
- FA-2 - Calibration of Conductivity Meter and Measurement of Field Conductivity
- FA-3 - Calibration of pH Meter and Measurement of Field pH
- WL-1 - Water-Level Measurement Procedure
- WL-2 - Procedure for Standardizing Steel Tapes.

Chain-of-Custody Procedures

Chain-of-custody procedures are contained in Procedures for Ground-Water Investigations (PNL 1989). The specific applicable procedure is number AD-2, Ground-Water Sample Chain-of-Custody Procedure. The history of the custody of each sample will be documented according to this procedure.

Quality Assurance for Ground-water Sample Analysis

The purpose of quality assurance (QA) is to determine and document the quality of the analytical results being produced by the laboratory and to bring potential problems with analyses to the attention of UST for corrective action as needed. Quality assurance will be conducted in accord with the PNL Quality Assurance Manual (PNL 1988). The QC effort has two main components: 1) routine internal checks performed by UST and 2) external checks conducted

by PNL to independently evaluate UST performance.

Internal quality control includes general practices applicable to a wide range of analyses as well as specific procedures stipulated for particular analyses. The quality control and quality assurance programs at UST are documented in the UST Quality Control Manual (Hembree et al. 1986) and the Quality Assurance Manual (Hembree and Lardy 1986). UST provides a quarterly Quality Control Report of Hazardous Substance Analyses to PNL for review by subcontracts, sample analyses management, quality control, and statistical task leaders of the ground-water monitoring program.

Pacific Northwest Laboratory will use both interlaboratory comparisons and spiked, replicate, and blank samples in evaluating the accuracy of results from UST. Interlaboratory comparisons using field samples are conducted to determine whether the results obtained by the primary laboratory, UST, are comparable to those obtained from other laboratories. Comparisons are currently being conducted for anions, volatile organic constituents, metals, and gross alpha and beta. Each month, replicate samples from selected wells are delivered to four different PNL laboratories. The results from these PNL laboratories are then compared with those from UST. Samples sent to PNL laboratories are from the same sampling set as those to be analyzed in duplicate by UST.

Replicate analyses of field samples are conducted to establish how much variability might be expected in the laboratory measurements performed on nearly identical samples. Trip (transport) blanks and transfer blanks are submitted to UST to determine whether environmental conditions during collection and transport of samples have affected analytical results. One set of trip blanks and one set of transfer blanks are submitted each sample period per sample area at the rate of at least one for one to 20 wells. These blanks are analyzed for volatile organic constituents. Blanks for a wide range of analyses are submitted to UST monthly to check for container or laboratory contamination.

Blind samples are submitted to UST to estimate the bias of analytical laboratory procedures and to determine when this bias exceeds control limits. Blind standard samples prepared by PNL containing metals, anions, herbicides, pesticides, and volatile organic compounds have been submitted quarterly since January 1986. These samples were prepared by PNL with materials supplied by Environmental Resource Associates. Additional blind samples prepared with materials supplied by the U.S. Environmental Protection Agency (EPA) were added in June 1986. The constituents included are ammonium ion, cyanide, semivolatile compounds, and an expanded number of pesticides and

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volatile organic compounds. Other constituents, not available in EPA performance samples, have also been added. These include thiourea, phosphorous pesticides, ethylene glycol, sulfide, perchlorate, and dioxin.

4.3 SOIL SAMPLING

Soil samples will be collected before the ISV test, during the drilling of two characterization boreholes in the crib, at the ground-water monitoring well, at the electrode placement holes, and at surface locations. These samples include both archive geologic samples and samples for laboratory analyses.

Sampling Interval

As shown in Table 5, archive geologic samples will be collected at 1-ft intervals, at boreholes 1 and 2. Continuous samples will be collected if possible. Geologic samples will be collected at 5-ft intervals at the monitoring well. Samples for laboratory analysis will be collected at approximately 2-ft intervals from boreholes 1 and 2, beginning at 6-ft, and at 5-ft intervals in well 3, beginning at 14 ft. The presence of contamination, as revealed by field measurements, will largely determine the precise collection intervals.

Surface Samples

At the ISV site, the intended locations of the two characterization and one ground-water monitoring well and the four electrodes will be identified. Surface soil samples will be taken at those locations for analysis before drilling begins. The dry well adjacent to the crib and the sump in the loading dock area will also be examined before beginning the ISV test. Samples will be collected as required from both the dry well and the sump area to determine contents and contamination present.

Sample Containers

All soil samples collected for inorganic and organic constituents (other than for VOAs) will be placed into precleaned 8-oz wide-mouth glass jars (I-CHEM or equivalent) capped with teflon-lined lids. Each VOA soil sample will be placed into a tared vial containing a known volume of high-purity methanol.

Sampling Method

Samples will be collected with a split spoon sampler, if possible, according to procedure D0-2, Split-Barrel Auger Sediment Sampling (PNL 1989) modified for cable-tool drilling. All modifications of the procedure will be documented in a field notebook or drill log. The actual number of samples will depend on the ability to obtain representative core samples in an area that is known to contain cobbles. If samples cannot be obtained with a split-spoon sampler or drive barrel, then a hard-tool bit will be used. NOTE: The procedures for drilling and collecting soil samples will be impacted by radionuclide contamination. The Radiation Work Procedure (RWP) will document the procedures/procedure modifications that apply to the drilling and sample collection tasks.

Split-spoon Sampling

A split-spoon sampler consists of an steel tube which is split lengthwise and has a hardened steel drive shoe at its base. For sampling, it is first lowered into the bottom of the hole, and then driven into the sediments. After the sampler is driven to the desired depth, it is pulled from the hole. Upon removal from the hole, the sampler is placed onto a flat work area where the drive shoe and top connector are removed. The top half of the split-spoon sampler is carefully removed while being tapped lightly with a hammer, if necessary.

The core will be scanned first using a G-M meter to determine if beta/gamma radiation is present. If readings significantly above background occur, then samples will be collected for laboratory analysis. An HNU Model PI-101 Photo-Ionizer will be then be used to indicate the presence of volatile organic compounds in the soil core. If significantly elevated readings are observed during the HNU scans, a sample will be collected from the highest reading within the core segment and retained for volatile organic analysis (VOA). The sample containers will be sealed, labeled, and stored at 0°C in an ice chest. A maximum of five samples will be collected for VOA.

All samples will be collected from the cores using a stainless steel spatula or plug cutter. The core will then be examined and measured, and samples will be taken for pH determination and soil classification. Sample locations, any observations, and the results of the field tests will be recorded on the drill log. The remaining core will be carefully tipped into a concave tray that has been lined with new aluminum foil. The core will be wrapped in aluminum foil and placed inside 12-mil polypropylene tubing. The ends of the polypropylene tubing will be sealed with tape and labeled with

the borehole number, depth, and core orientation. The core will then be placed inside an ice chest and preserved until needed for further analysis or discarded.

Any sediment collected in the split-spoon sampler that is too unconsolidated to store as a core sample, will be collected and stored individually in a glass jar. After each core hole is completed, the split-spoon sampler will be cleaned using a scrub brush and water with a detergent solution added; it will then be rinsed with distilled water.

Sampling During Hard-tool Drilling

If drilling with a hard-tool bit is required, then samples will be brought to the surface via a bailer and transferred into a clean stainless steel bucket. Samples can then be collected from this bucket using a stainless steel spatula or spoon and transferred into glass jars. Samples for volatile organic analyses will not be collected during hard-tool drilling.

Sample Analysis

Table 6 contains a list of parameters to be measured for, the specific methods used on the soil samples, and the analytical laboratory. The analysis will be conducted by PNL, UST, or another subcontractor. The procedure for determining the concentrations of metals in soil is based upon the use of energy-dispersive x-ray fluorescence (XRF) (PNL Method PNL-SP-19). Five soil samples, identified by the XRF procedure, containing the highest concentrations of EPA priority metals will be tested for EP Toxicity. Ten percent of the soil samples will be analyzed for the Appendix 9 list. Samples will be selected by the results of the XRF and TOC analysis. Ten percent of the samples will be analyzed for gamma-emitting radionuclides using standard high-resolution counting techniques. The samples will be selected using the results of the G-M scans during field sampling and the down hole well logging.

NOTE: If the radioactivity of the soil samples exceeds 1 millirem at the outer surface of the container, the samples will be analyzed by PNL or another subcontractor instead of UST.

Sample Preparation

Each sample collected in the field will be homogenized, using a jar mill if necessary. After mixing, samples will be aliquoted by cone and quartering. The selected samples will then be submitted for the respective analyses listed in Table 6.

Although about 150 samples are expected to be collected in the field, only half of the samples will be analyzed for one or more constituents. Initially, samples will be selected at depth intervals of 2 ft; however, if notations on the field log indicate a change in lithology, other obvious physical changes in the soil characteristic, or observed high reading with the G-M or HNU scan this sample may will be analyzed in lieu of the 2-ft sample. If large variability is observed in the analytical results from the soil analysis and upon agreement with the project manager, additional samples may be selected for analysis.

TABLE 6. Soil Samples, Methods, and Laboratories

<u>Parameter</u>	<u>Matrix</u>	<u>Method</u>	<u>Lab</u>
Arsenic	Soil	PNL-SP-19	PNL
Chromium	Soil	PNL-SP-19	PNL
Lead	Soil	PNL-SP-19	PNL
Selenium	Soil	PNL-SP-19	PNL
Oxalate	Soil	Modified EPA 300.7	PNL
Sulfamate	Soil	Modified EPA 300.7	PNL
Appendix 9 List*	Soil	Listed by US Testing	US Testing
TOC	Soil	EPA Method 9060	US Testing
Volatile Organics	Soil	EPA Method 5030/8020	PNL
Gamma Ray Counting	Soil	Method in Appendix	PNL
EP Toxicity	Soil	EP Toxicity Test	PNL
ICAP Metals	Leachate	EPA Method 200.7	PNL
Lead	Leachate	EPA Method 7421	PNL
Mercury	Leachate	EPA Method 7471	PNL
Cadmium	Leachate	EPA Method 7131	PNL
Arsenic	Leachate	EPA Method 7060	PNL
Selenium	Leachate	EPA Method 7740	PNL
Moisture Content	Soil	ASTM, 1986	PNL

* Includes: total organic carbon, total carbon, ICP metals or equivalent, Se, Te, Pb, VOA, aromatic organics, pesticides, herbicides, thiourea, phosphorous pesticides, PCB, dioxin, cyanide, gross alpha, gross beta

Quality Control Checks for Soils

No soil blanks will be submitted to the analytical laboratory for analysis because a universal blank matrix does not exist for solid samples. A minimum of two background samples will be collected at the site in areas that do not appear to have been impacted by human activities. Background soil samples may

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also be generated during the drilling of the ground-water monitoring well.

Ten percent of the samples, analyzed by each analytical method, will be analyzed in duplicate. This information will be used to determine precision of the analysis. No standard soils, with known concentration of contaminants, will be submitted to the analytical laboratory for analysis.

Accuracy of the data will be assessed from sample spike recoveries. Selected samples will be spiked before extraction and analyzed. Other selected samples will be extracted, spiked, then analyzed. There will be no field spiking of samples. Further investigation will be initiated to identify specific problems if discrepancies are discovered when comparing duplicate results.

The reporting of the data will be in concentration units of ppm, ppb, or pCi/g, whichever is most suitable. Soil concentration of metals in soil will be recorded as weight of a selected metal/dry weight of soil. Soil concentrations for the organic constituents will be reported as weight of organic/wet soil weight.

Moisture Samples

Moisture samples will be collected concomitant with each split-spoon or core-barrel sample collected for laboratory analyses. Moisture samples will be collected in a moisture tin, sealed with tape, labeled, and sealed in plastic bags.

Soil pH

Soil pH will be measured on all samples sent to the laboratory for analysis. The procedure used is according to Peech (1965) and consists of measuring the soil pH in water with a portable pH meter.

Sample Documentation

All sample collection activities should be documented on the drill log and should be consistent with PNL procedure D0-1, Collection and Documentation of Borehole Samples and Well Construction Data (PNL 1989). This includes borehole sample descriptions, well construction data, and sample collection documentation. Sample descriptions include (as time permits): textural classification, estimated particle size distribution, sorting, sedimentary structures, gross mineralogy, roundness, color, odor, and reaction to 10% HCl. Well construction data include: well status, a description of all well construction activities (type/lengths of casing used, drill rates, amounts of

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drilling supply water used, etc.), and well development activities. Sample collection documentation includes labeling and documenting sampling events on the drill log.

Chain-of-Custody Procedures

The chain-of-custody procedures to be used are the same as those specified in section 4.2 (Ground-water Sampling). Only those samples collected for laboratory analysis of hazardous or radioactive material will follow this chain-of-custody procedure.

Soil Gas Measurements

To determine the presence of volatile organic compounds, soil gas will be measured at ten points identified around the perimeter of the crib before the ISV demonstration test. Soil gas samples will be extracted from the soil and analyzed for the following compounds: 1,1,1 trichloroethane (TCA), carbon tetrachloride (CCl_4), trichloroethylene (TCE), 1,2 dichloroethane, 1,1 dichloroethane, tetrachloroethylene (PCE), cis and trans dichloroethylene, chloroform, methylene chloride, chlorobenzene, benzene, toluene, ethyl benzene, m+p-xylene, o-xylene, methylethyl ketone (MEK), methylisobutyl ketone (MIBK), hexane, heptane, and octane. Procedures for soil gas measurements are given in Appendix C.

In Situ Gamma Counting with a Down-hole Intrinsic Germanium Detector

In situ gamma ray logging will be conducted in boreholes 1 and 2, the monitoring well, and in the four electrode holes using a down-hole intrinsic germanium detector. The seven holes will be logged at depth intervals of 2 ft. This will result in about 70 discrete points being logged. The resulting spectra acquired at each point will be deconvoluted and analyzed for gamma-ray emitting radionuclides including: ^{60}Co , ^{90}Sr , ^{137}Cs , ^{155}Eu , ^{239}Pu , and ^{238}U . The in situ gamma ray logging will be done in accordance with established PNL methodology (Brodzinski and Hensley 1982).

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APPENDICES

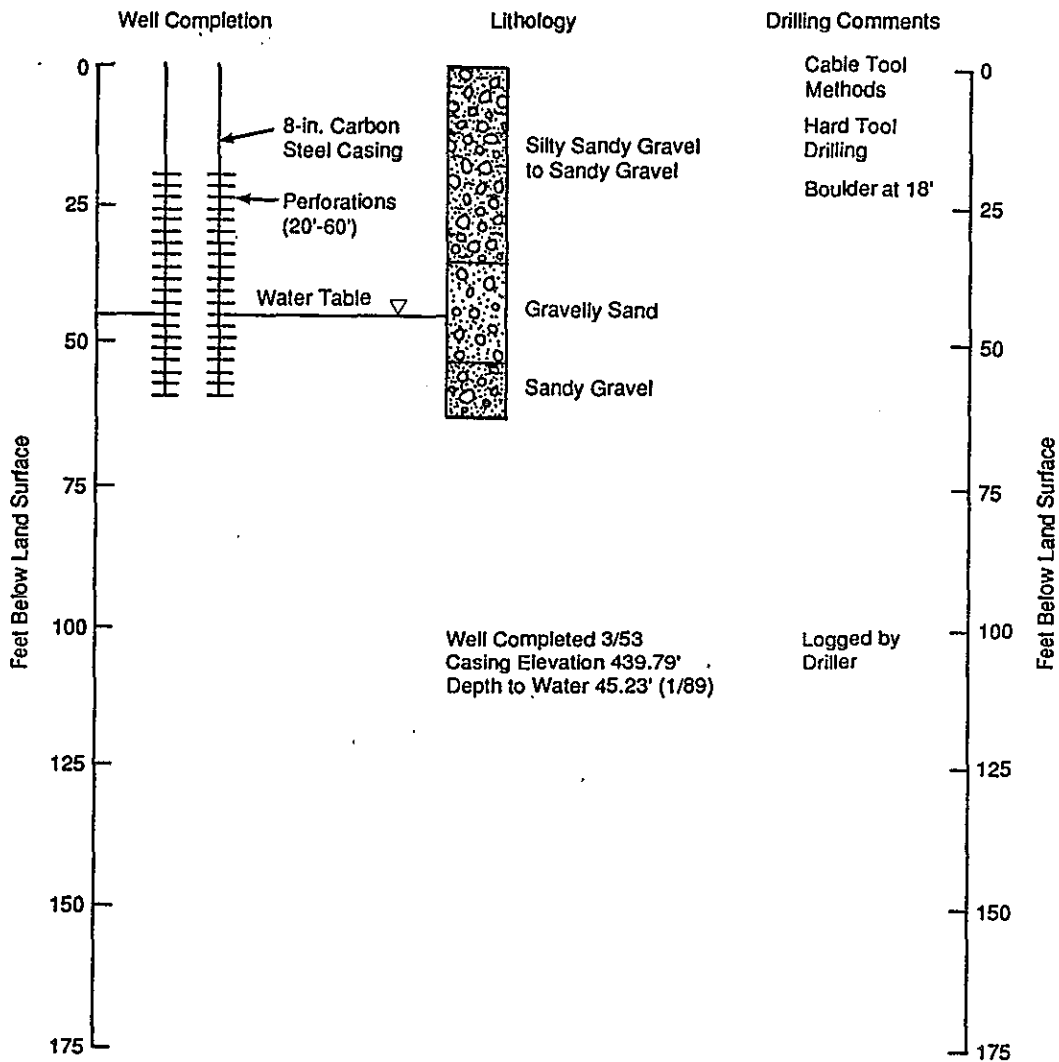
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APPENDIX A

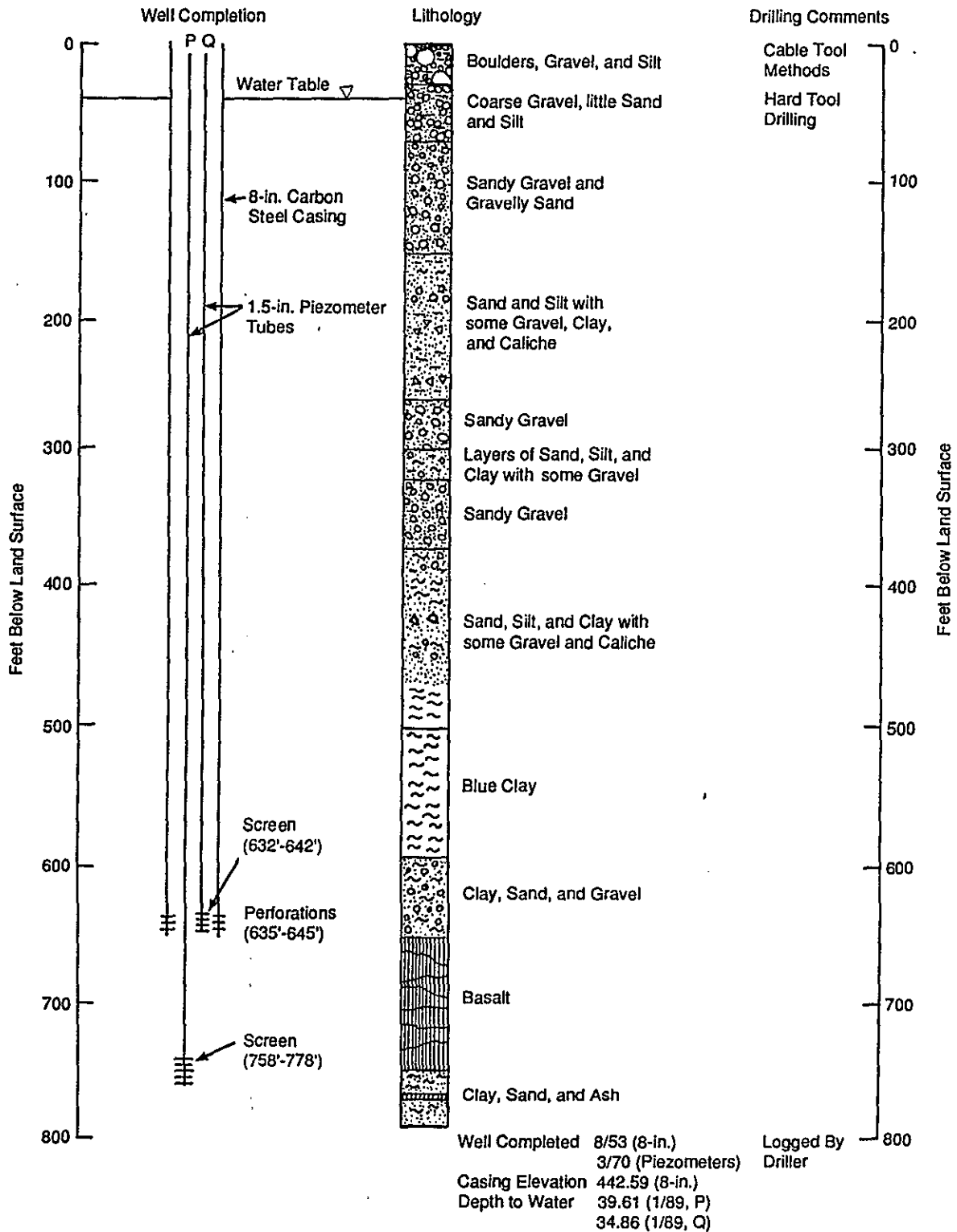
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FOR WELLS IN THE 100-B AREA

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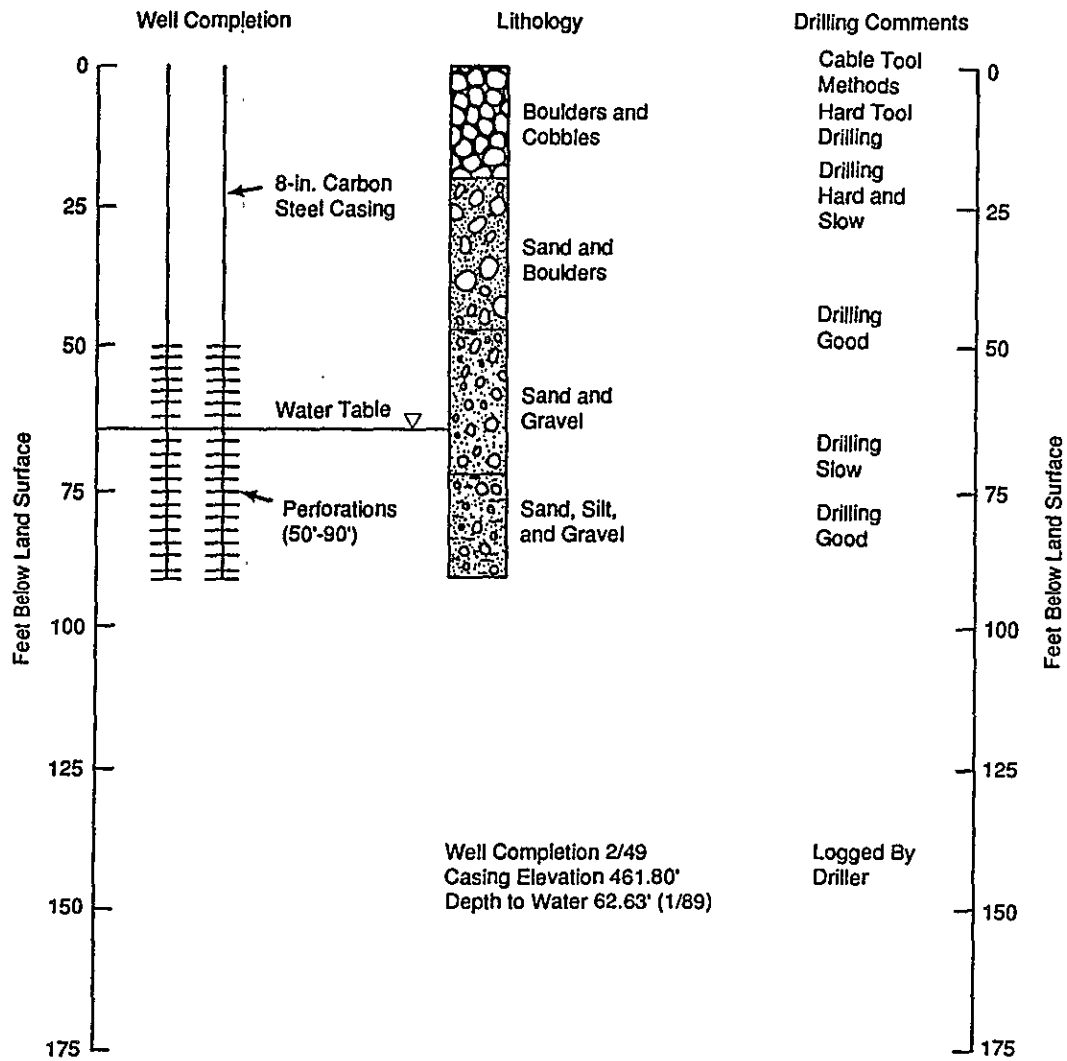
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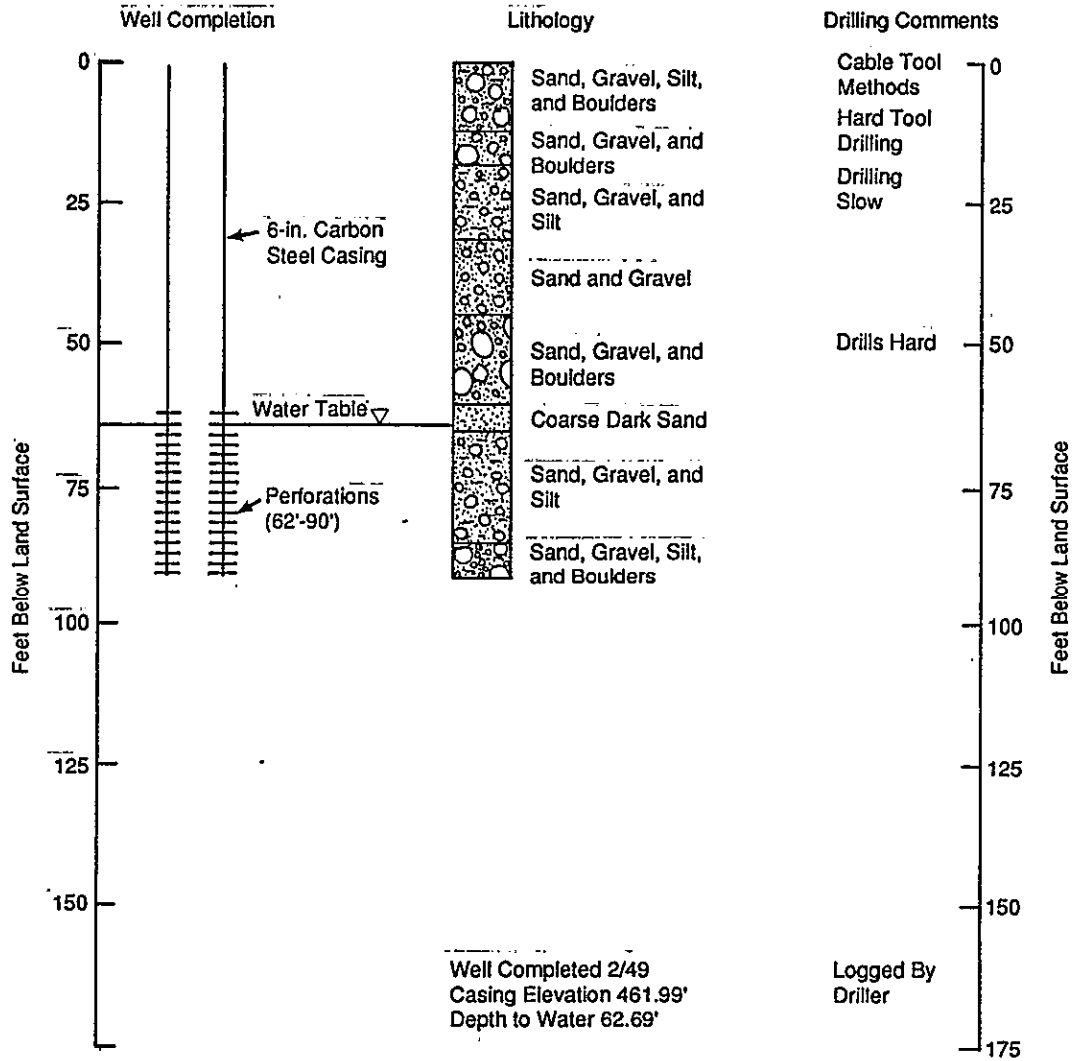
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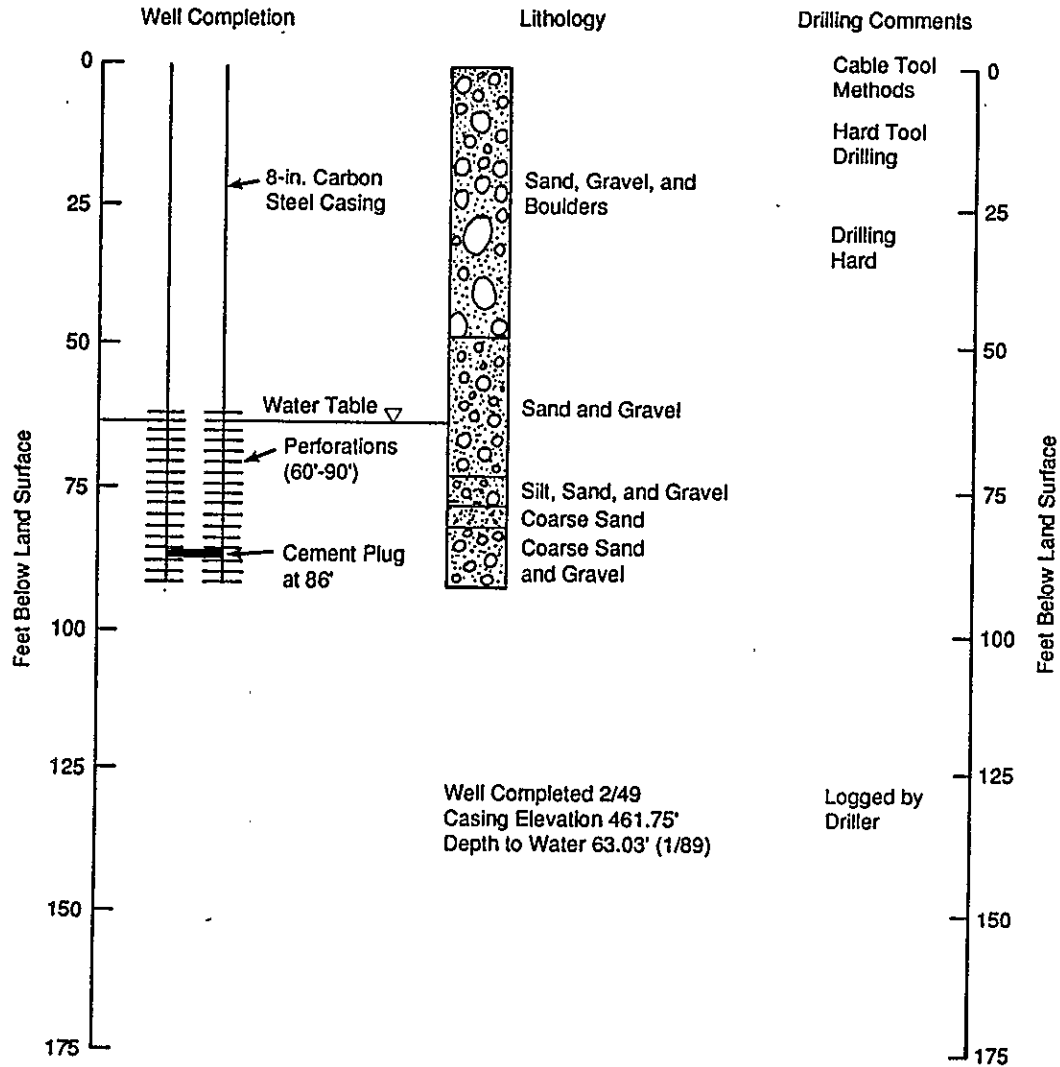


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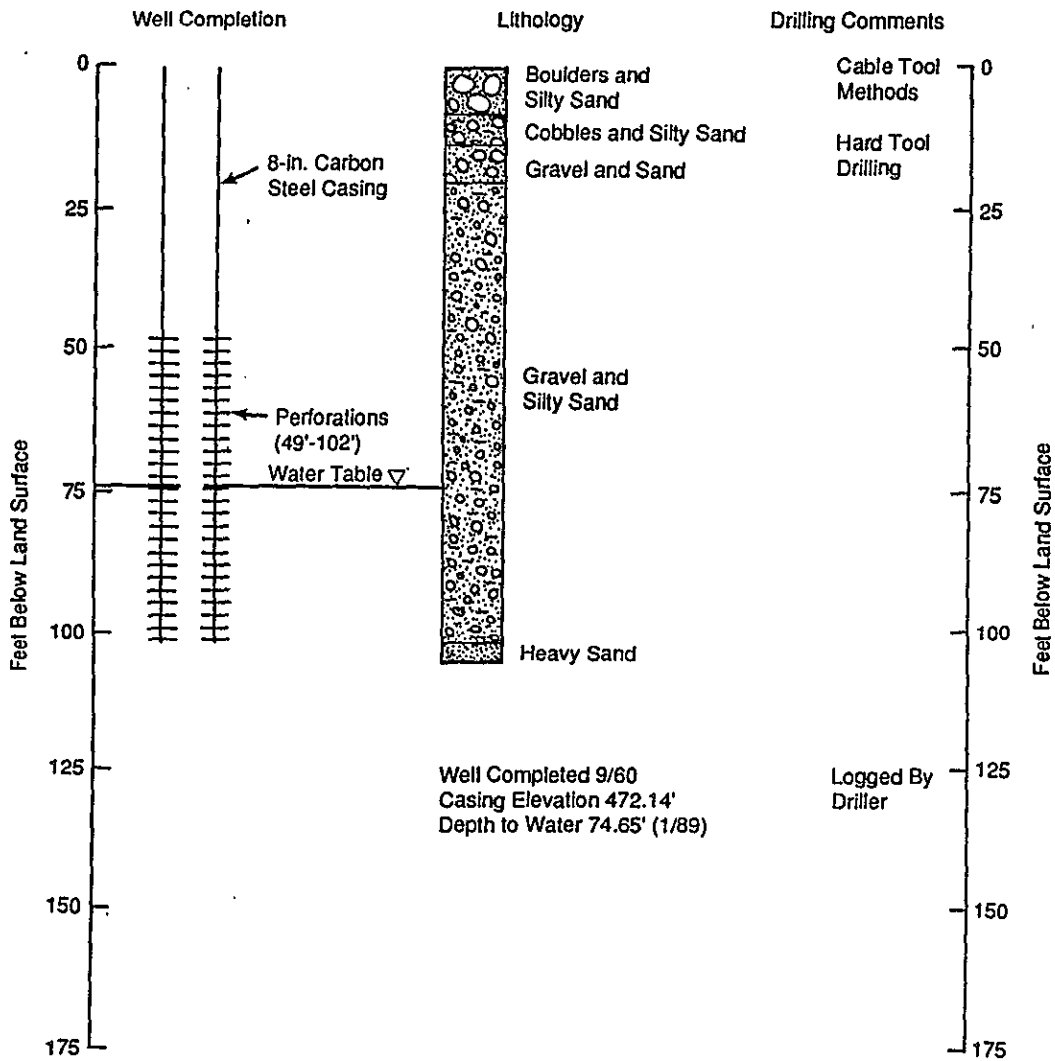
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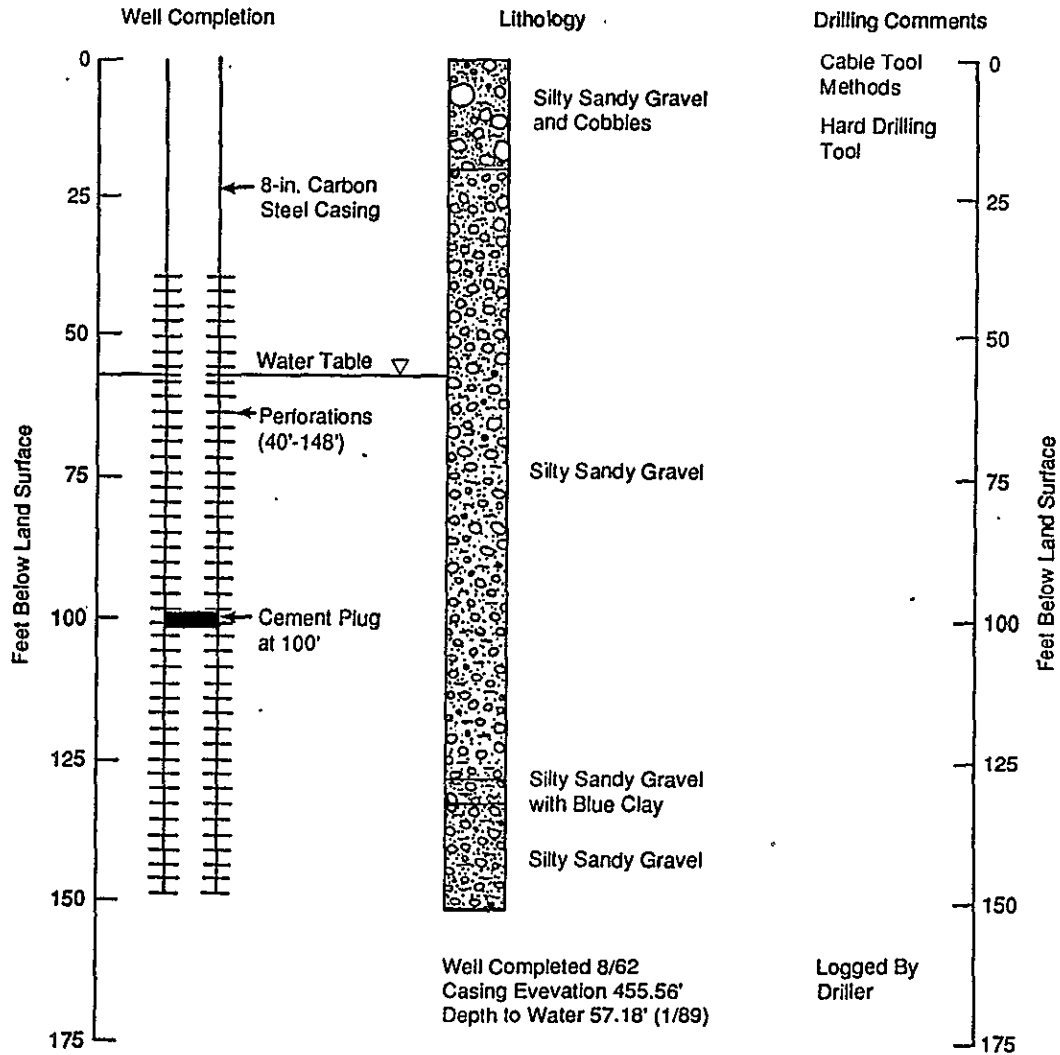
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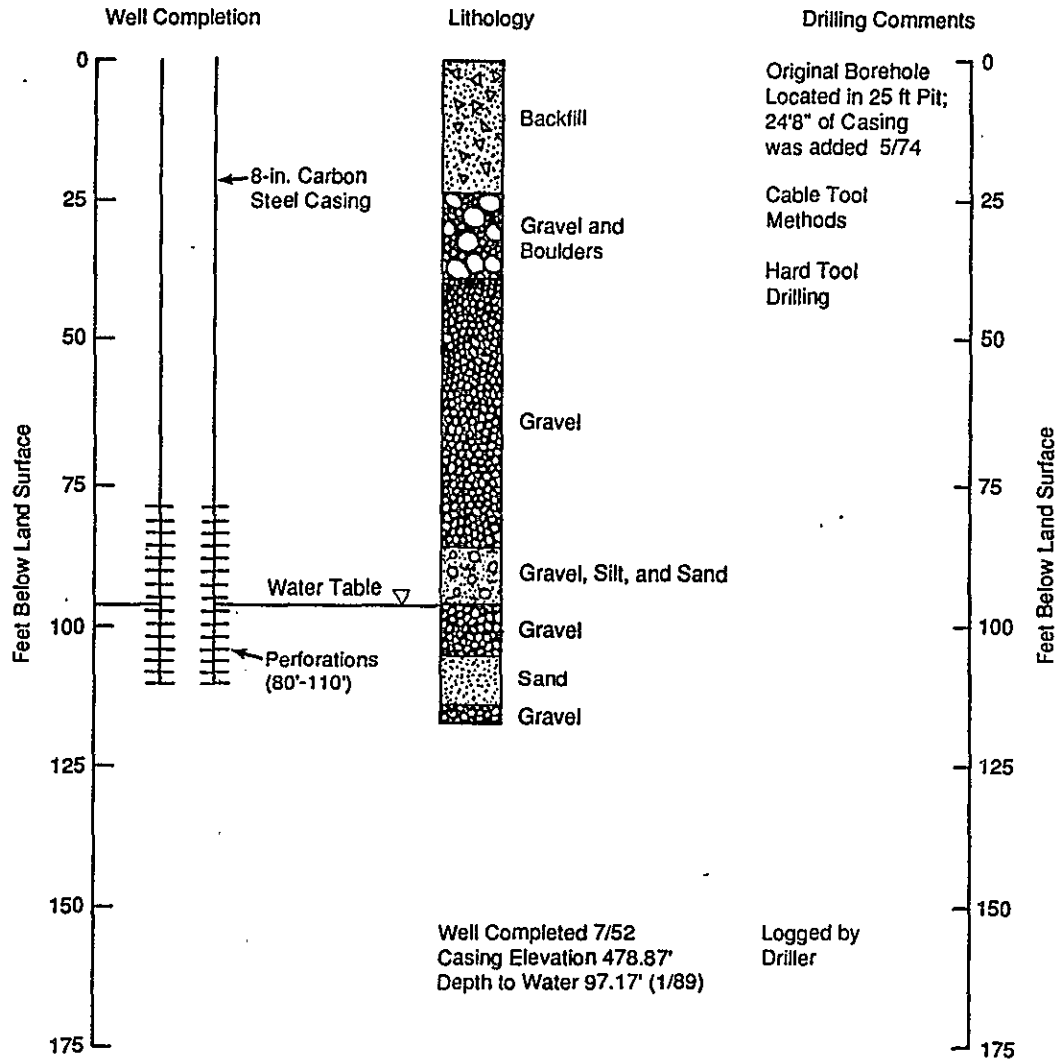


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APPENDIX B

PRESERVATION TECHNIQUES, ANALYTICAL
METHODS, AND DETECTION LIMITS

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TABLE B.1. Preservation Techniques, Analytical Methods Used, and the Current Detection Levels for Listed Constituents as of January 1, 1989

Constituent	Collection and Preservation ^(a,b)	Analysis Methods ^(c)	Detection Limit, ppb ^(d)
ICP METALS - Unfiltered/Filtered			
Beryllium			3
Strontium			10
Zinc			5
Calcium			50
Barium			6
Cadmium			5
Chromium			10
Lead			30
Silver			10
Sodium			200
Nickel			10
Copper			10
Vanadium	P, HNO ₃ to pH<2	SW-846, ^(e) #6010	5
Antimony			100
Aluminum			150
Manganese			5
Potassium			100
Iron			30
Magnesium			50
Boron			10
Cobalt			20
Lithium			10
Molybdenum			40
Silicon			50
Tin			30
Titanium			60
Zirconium			50
Arsenic	P, HNO ₃ to pH<2	SW-846, #7060	5
Mercury	G, HNO ₃ to pH<2	SW-846, #7470	0.1
Selenium	P, HNO ₃ to pH<2	SW-846, #7740	5
Lead	P, HNO ₃ to pH<2	SW-846, #7421	5
ANIONS BY IC^(f)			
Nitrate			500
Sulfate			500
Fluoride	P, None	EPA Method	500
Chloride		300.0 ^(g)	500
Phosphate			1000
Bromide			1000
Nitrite			1000

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TABLE B.1. (contd)

Constituent	Collection and Preservation ^(a,b)	Analysis Methods ^(c)	Detection Limit, ppb ^(d)
<u>PESTICIDES</u>			
Endrin	G, None	SW-846, #8080	0.1
Methoxychlor			3
Toxaphene			1
Lindane (four isomers)			0.1
<u>HERBICIDES</u>			
2,4-D	G, None	SW-846, #8150	2
2,4-5-TP silvex			2
2,4,5-T			2
<u>VOLATILE ORGANICS (VOA)</u>			
Carbon tetrachloride	G, No headspace	SW-846, #8240	5
Benzene			5
Methylethyl ketone			10
Toluene			5
1,1,1-trichloroethane			5
1,1,2-trichloroethane			5
Trichloroethylene			5
Tetrachloroethylene			5
Xylene (O, P)			5
Chloroform			5
1,1 dichloroethane			5
1,2 dichloroethane			5
Trans-1,2 dichloroethylene			5
Methylene chloride			5
Vinyl chloride			10
Xylene (M)			5
p-dichlorobenzene			5
Methyl isobutyl ketone			10
<u>RADIOLOGICAL</u>			
Radium	P, HNO ₃ to pH<2	SW-846, ^(h) #9315	1 pCi/L
Gross alpha	P, HNO ₃ to pH<2	SW-846, #9310	4 pCi/L
Gross beta	P, HNO ₃ to pH<2	SW-846, #9310	8 pCi/L
Tritium	P, None	ASTM, D2476-81	500 pCi/L
<u>OTHER</u>			
Coliform bacteria	P, None	SW-846, #9131	2.2 MPN
Temperature	Field measurement	PNL-MA-567, ⁽ⁱ⁾ FA-1	

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TABLE B.1. (contd)

Constituent	Collection and Preservation ^(a,b)	Analysis Methods ^(c)	Detection Limit, ppb ^(d)
Specific conductance	Field measurement	PNL-MA-567, FA-2	
pH	Field measurement	PNL-MA-567, FA-3	
Total organic halogen, low detection level	G, H ₂ SO ₄ to pH<2 No headspace	SW-846, #9020	10
Total organic carbon	G, H ₃ PO ₄ to pH<2	SW-846, #9060	2000
Total carbon	G, None	SW-846, #9060	2000
Ammonium ion	G, H ₂ SO ₄ to pH<2	ASTM D1426-D ^(j)	50
Phenol	G, None	SW-846, #8040	10
Cyanide	P, NaOH to pH<2	SW-846, #9010	10
Hydrazine	G, HCl	ASTM D1385	30
Total dissolved solids	P, None	Std. Methods 209B ^(k)	--

(a) P, plastic; G, glass.

(b) All samples will be cooled to 4°C upon collection.

(c) Constituents grouped together are analyzed by the same method.

(d) Detection limit units except where indicated.

(e) Adapted from USEPA Method 6010 (EPA 1986).

(f) IC, ion chromatography.

(g) In-house analytical method from UST Procedure Manual UST-RD-PM; adapted from Method 300.0, EPA-600/4-84-017 (March 1984).

(h) The method also references ASTM D2460, "Standard Test Method for Radionuclides of Radium in Water"; and "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA-600/4-80-032, edited by Herman L. Krieger and Earl L. Whittaker, 1980, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

(i) (PNL 1989).

(j) By ion selective electrode.

(k) Standard Methods for the Examination of Water and Wastewater, 16th ed., 1985, published jointly by the American Public Health Association, American Water Works Association and Water Pollution Control Federation (ALPHA 1985).

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TABLE B.2. Preservation Techniques, Analytical Methods Used, and the Current Detection Levels for Additional Constituents on the 9905 and Appendix IX Lists^(a)

Constituent	Collection and Preservation ^(b,c)	Analysis Methods ^(d)	Detection Limit, ppb ^(e)
<u>ICP METALS, ENHANCED ADDITIONS</u>			
Thallium	P, HNO ₃ to pH<2	SW-846, #7840,	5
<u>THIOUREA GROUP, ENHANCED ADDITIONS</u>			
Thiourea			200
1-Acetyl-2-thiourea			200
1-(O-Chlorophenyl) thiourea			200
Diethylstilbesterol	G, None	SW-846, #8330	200
Ethylenethiourea		(modified)	200
1-Naphthyl-2-thiourea			200
N-Phenylthiourea			500
<u>PESTICIDES, ENHANCED ADDITIONS</u>			
Aldrin			0.1
Chlordane			1
4,4'-DDD			0.1
4,4'-DDE			0.1
g4,4'-DDT			0.1
Endosulfan I			0.1
Endosulfan II	G, None	SW-846, #8080	0.1
Endosulfan sulfate			0.5
Haptachlor			0.1
Heptachlor epoxide			0.1
Kepone			1
Dieldrin			0.1
Chlorobenzilate			300
<u>PHOSPHOROUS PESTICIDES</u>			
Carbophenothion			2
Tetraethylpyrophosphate			2
Disulfoton			2
Dimethoate	G, None	SW-846, #8140	2
Methyl parathion			2
Parathion			2
Phorate			2

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TABLE B.2. (contd)

Constituent	Collection and Preservation ^(b,c)	Analysis Methods ^(d)	Detection Limit, ppb ^(e)
<u>DIRECT AQUEOUS INJECTION</u>			
Acrylamide	G, None	SW-846, #8240 DAI ^(f)	10,000
Allyl alcohol			2,500
Chloroacetaldehyde			16,000
3-chloropropionitrile			4,000
Ethyl carbamate			5,000
Ethyl cyanide			2,000
Ethylene glycol			10,000
Isobutyl alcohol			1,000
Paraldehyde			2,000
N-propylamine			10,000
2-probyb-1-ol	8,000		
<u>DIOXINS</u>			
PCDDs	G, None	SW-846, #8280	0.01
PCDFs			0.01
2,3,7,8 TCDD			0.01
<u>VOAs, ENHANCED ADDITIONS</u>			
1,4-dioxane	G, No headspace	SW-846, #8240	500
Pryidine			500
Acrolein			10
Acrylonitrile			10
Bis(chloromethyl) ether			5
Bromoacetone			5
Methyl bromide			10
Carbon disulfide			10
Chlorobenzene			5
2-chloroethylvinyl-ether			5
Methyl chloride			10
Chloromethylmethyl-ether			5
Crotonaldehyde			10
1,2-dibromo-3-chloropropane			10
1,2-dibromoethane			10
Dibromomethane			10
1,4-dichloro-2-butene			10
Dichlorodiflouro-methane			10
1,2-dichloropropane			5
N-N-diethylhydrazine			10
1,1-dimethylhydrazine			10

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TABLE B.2. (contd)

Constituent	Collection and Preservation ^(b,c)	Analysis Methods ^(d)	Detection Limit, ppb ^(e)
1,2-dimethylhydrazine			10
Iodomethane			10
Methacrylonitrile			10
Methanethiol			10
Pentachloroethane			10
1,1,2,2-tetrachloroethane			5
Bromoform			5
Trichloromethanethiol			10
Trichloromonofluoromethane			10
1,2,3-trichloropropane			10
Acetonitrile			10
Formaldehyde	G, No headspace	SW-846, #8240	500
Ethylene oxide			10
Ethyl methacrylate			10
Ethyl benzene			5
Styrene			5
Bromodichloromethane			5
Dibromochloromethane			5
2-hexanone			50
1,3-dichloropropene			5
Allyl chloride			100
Chlorethane			10
Propionitrile			5
Vinyl acetate			5
Additional VOAs ^(g)			

SEMIVOLATILE ORGANIC ANALYSIS (ABN)

Chlorobenzene			10
Cresol			10
1,2-dichlorobenzene			10
1,3-dichlorobenzene			10
p-dichlorobenzene			10
Hexachlorobenzene			10
Pentachlorobenzene			10
Pentachlorophenol	G, None	SW-846, #8270	50
1,2,4,5-tetrachlorobenzene			10
1,2,4-trichlorobenzene			10
Hexachlorophene			10
Naphthalene			10
1,2,3-trichlorobenzene			10
Phenol			10
1,3,5-trichlorobenzene			10
1,2,3,4-tetrachlorobenzene			10

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TABLE B.2. (contd)

Constituent	Collection and Preservation ^(b,c)	Analysis Methods ^(d)	Detection Limit, ppb ^(e)
1,2,3,5-tetrachlorobenzene			10
Kerosene			10
Strychnine			50
Maleic hydrazide	G, None	SW-846, #8270	500
Nicotinic acid			100
Tributylphosphate			10
Additional semivolatiles ^(h)			
OTHER			
Polychlorinated biphenyls	G, None	SW-846, #8080	1
Perchlorate	P, None	70-IC ^(i,j)	500
Sulfide	P, NaOH/Zinc acetate	SW-846, #9030	1,000
Citrus red #2	G, None	AOAC #34.015B	1,000

- (a) WAC 173-303-9905, Dangerous Waste Constituents List; and EPA Appendix IX, Ground-Water Monitoring List, 40 CFR 264.
- (b) P, plastic; G, glass.
- (c) All samples will be cooled to 4°C upon collection.
- (d) Constituents grouped together are analyzed by the same method.
- (e) Detection limit units except where indicated.
- (f) DAI, direct aqueous injection.
- (g) Tentatively identified compounds are listed when seen, but there are no established detection limits for these.
- (h) There are more than 100 additional semivolatile compounds on the "long list" that are not listed here. Most of these analyses have a detection level of 10 ppb.
- (i) In-house analytical method from UST Procedure Manual, UST-RD-PM, adapted from Method 300.0, EPA-600/4-84-017 (March 1984).
- (j) IC, ion chromatography.

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APPENDIX C

SOIL GAS MEASUREMENTS

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C1. INTRODUCTION

This appendix describes the methods to be used for soil gas measurements at the 116-B-6-1 site. Since there is no method universally accepted or mandated by regulation for performing soil-gas surveys, considerable latitude is possible for the exact choice of method employed. Soil-gas probes are typically placed 3 to 6 ft below the surface. If possible, all samples should be taken at the same penetration depth to simplify interpretation. A constant depth of 4 ft will be employed where possible for all sample probes. Probe penetration of less than 36 in. will be considered to be penetration refusal, and the probe will be moved to a new location. Gas samples drawn through the probe by a low-volume pump may be collected either by a gas-sampling syringe or a sorption trapping device (i.e., Tenax, charcoal, or both). Equipment for both methods is available at PNL.

The sorption trap method offers much greater sensitivity at the expense of analytical complexity. The syringe method is of adequate sensitivity and is in general preferable because of its simplicity, speed, and reliability. All work performed by PNL will use the direct sampling method employing gas-tight syringes of volumes ranging from 0.1 to 5 mL. Samples will also be collected in 500-ml flow-through gas sampling flasks so that measurements may be repeated in the laboratory for improved dynamic range. Analysis of the drawn sample is performed by gas chromatography (GC) employing detectors with both broad-spectrum sensitivity (i.e., flame ionization [FID]) and halogen selectivity (i.e. electron capture [ECD]). The electron capture detector in particular is extremely sensitive, making it possible to use relatively small sample volumes. The GC system employed by PNL uses a split inlet with separate capillary columns connected to ECD and FID detectors. The analytical work itself is performed according to appropriate EPA guidelines for analysis of volatile organics by gas chromatography.

Suitable calibration standards are available that permit the most commonly detected species to be identified and quantified. These include at a minimum the following compounds: 1,1,1 trichloroethane (TCA), carbon tetrachloride (CCl_4), trichloroethylene (TCE), 1,2 dichloroethane, 1,1 dichloroethane, tetrachloroethylene (PCE), cis and trans dichloroethylene, chloroform, methylene chloride, chlorobenzene, benzene, toluene, ethyl benzene, m+p-xylene, o-xylene, methylethyl ketone (MEK), methylisobutyl ketone (MIBK), hexane, heptane, and octane. Calibration for other species may also be performed if needed to identify unknowns detected during actual field work.

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C2. SAMPLING PROBES

Sampling probes are constructed according to the design of LaBrecque et al. Detailed machine drawings of the probe and associated hardware have been provided by Kerfoot and Barrows. The PNL version of the probe has been modified somewhat: a sacrificial penetrator tip is slipped over the end to prevent the sampling ports from clogging during probe entry. These tips are mass-produced in the 300 Area Machine Shop.

Several different probe sizes ranging from 5 to 8 ft have been used; for this work, 6-ft probes will be used exclusively. The probes are of all stainless steel construction to minimize carryover of volatile organics. Probes will be cleaned with methylene chloride to remove machine oil prior to final assembly. Following assembly, the probes are pressure leak checked.

Probes will be placed in the ground to an exact depth of 4 ft by hammering with a vibratory hammer. Both electric and pneumatically powered percussion hammers are available. A slide hammer is also available for inserting probes manually in remote areas. Following penetration to the required depth, the probe will be withdrawn 2 in. to separate it from the sacrificial tip. For work in very rocky soil, a gasoline powered hand auger with a 1.5-in. bit can be used to facilitate entry of the probe. In that case, the auger will drill a hole to within 6-in. of the required depth. The probe will then be placed in the hole and hammered to the required depth. The hole will be carefully backfilled with spoil and firmly tamped down. The probe will be removed by reverse hammering, if necessary after sampling is completed.

C3. SAMPLE COLLECTION

The sample collection train consists of a 1/8-in.-dia stainless steel tube connected to a gas-sampling bulb with Cajon type quick disconnect fittings. Gas is drawn through a 500-mL gas-sampling bulb by a battery-powered pump. Two pumps are currently available, an Aircheck Model 224 PC-3 (1-4 LPM) and a Supelco Model SP-13P (0.2 LPM). The Aircheck pump will be used at a flow rate of 1 LPM. The Supelco pump is available as a backup. The rotameter flow meter on the pump may be used to verify the presence of flow through the probe. A sensitive pressure sensor in the pump shuts the pump down automatically if the pump starts to pull vacuum due to a clogged tip. If the probe tip is found to be plugged with soil, the probe will be removed, cleared and reinserted. The pump will be run for at least 5 minutes prior to sampling to completely purge the gas-sampling bulb. The sample bulb will then be valved off, labeled, and removed to the motor home for analysis. Sample location, pump time, and any other pertinent observations, including

meteorological conditions, will be recorded in the field notebook. The probe may be cleaned and relocated while the sample is being analyzed. The air-sampling pump should be placed on its battery charger at the completion of each day's sampling.

C4. INSTRUMENTATION

Samples will be analyzed with a Hewlett-Packard Model 5880A gas chromatograph. The GC is equipped with two identical J&W DB-624 30-m X 0.53-mm fused silica capillary columns. The DB-624 columns are coated with a cross-linked and bonded stationary phase composed of cyanopropyl, phenyl, dimethylsiloxane. The two columns are teed together at the inlet and are routed to separate electron capture (ECD) and flame ionization (FID) detectors. Samples are introduced via a Tekmar Model LSC-3 purge and trap unit. They enter the LSC-3 in either gaseous or liquid form through the same inlet fitting, thus permitting calibration of the system by VOA water standards. EPA water standards may also be used for QA checks. The LSC-3 contains a Tenax sorption trap. Samples are thermally desorbed from the Tenax trap and transferred to the columns through a heated transfer line. A pneumatic valve actuator has been added to the LSC-3 to permit the purge and trap cycle to be fully automated by the GC run table. The HP 5880A is equipped with two separate integrators to simultaneously integrate data from both detectors. An IBM AT computer is also available for chromatography data reduction. The AT employs Nelson Analytical Turbochrom chromatography software and Nelson Analytical dual channel chromatography interfaces.

C5. ANALYTICAL METHODOLOGY

Analytical measurements will be performed in accord with the guidelines in EPA SW-846 Method's 8010 (halogenated volatile organics) and 8015 (nonhalogenated organics). Several significant departures from the method will be employed. The separation column used will be a DB-624 Megabore capillary column, which provides much higher performance than the packed column specified in the EPA method while still being fully compatible with purge and trap sample introduction. The DB-624 is newly developed, and no reference method taking advantage of its remarkable properties has yet been published by the EPA. The detector used will be an electron capture detector rather than the electrolytic conductivity detector more commonly employed for Method 8010 work. The electron capture detector is considerably more sensitive and has adequate halogen selectivity to satisfy the method's goals, particularly when used with a capillary separation column.

The method of sample introduction will be modified to accommodate either gas or water samples. The purge and trap cell will be filled with 5 mL of boiled, deionized water. Gas samples in gas-tight syringes will be introduced through the normal sample inlet of the purge and trap unit, bubbled through the water, and passed through to the sorption trap. The initial injection will be followed by a second volume of ambient air to clear the syringe and sample inlet of any residual material. The GC will then cycle through a complete purge and trap cycle according to EPA guidelines and manufacturer's recommendations. Calibration will be performed as described below with water samples; however, the units used for calibration will be micrograms of total sample recovered rather than concentration. Gas concentrations can then be manually calculated by dividing by the injected volume.

The quality of soil gas data will be assessed through the use of replicate measurements, blanks, and standards. In general, at least one replicate measurement and standard shall be analyzed for every ten points, and blanks shall be run for every tenth sample.

Calibration

External calibrations will be performed with water samples prepared according to standard methods and introduced into the purge and trap unit according to manufacturer's recommendations. Linearity will be verified for five concentration ranges. Working standards will be prepared by dilution with boiled, deionized water of stock solution of the materials of interest dissolved in methanol. High-end calibrations will be performed for the following species at the specified concentrations: chloroform (10 ppb), 1,1,1 trichloroethane (6 ppb), tetrachloroethene (3 ppb), carbon tetrachloride (3 ppb), and trichloroethene (6 ppb). Two-, five-, ten-, and twenty-fold dilutions with boiled, deionized water will then be made to verify linearity. Response factors will be computed for both the ECD and FID channels. Detection limits will be calculated by reference to the low-end standard and ambient air blank. Calibration factors will be verified once daily prior to sample analysis with a mid-range standard. An appropriate EPA-EMSL VOA standard will be analyzed at least once per week for to validate the method. Calculated recoveries must be within the range specified by EPA for all species. If recoveries are not within the specified range, out-of-control procedures must be implemented to remedy the problem before proceeding. In addition to the species discussed above, stock solutions will also be available for the following materials: 1,2 dichloroethane, 1,1 dichloroethane, cis and trans dichloroethylene, methylene chloride, chlorobenzene, benzene, toluene, ethyl benzene, m+p-xylene, o-xylene, methylethyl ketone.

methylisobutly ketone, hexane, heptane, and octane. Dilutions of those materials shall be used to accurately determine retention time; however, those species will not normally be quantified unless found in actual soil gas samples.

Validation

The validity of the calibration procedure will be validated by two independent methods:

- 1) Gas standards for the materials of interest will be prepared by adding 10- μ L samples of stock solution in methanol to a gas-sampling bulb of accurately known volume. The volume of the bulb will be determined by filling with water and weighing. Evaporation of the methanol sample solution inside the bulb will produce a dilute material-air mixture of accurately known concentration. Bulbs will be heated to 100 °C for at least 1 hour to promote complete mixing. Samples drawn from the gas-sampling bulb will be injected into the GC to compare with samples of the same material introduced into the purge and trap unit as water solution.
- 2) An alternate method used for validation will employ a VIC-Metronics Model 340 Dynacalibrator to produce a gas stream of accurately known concentration. Gas permeation tubes containing MIBK, PCE, CC14, TCA, TCE, and MEK are available for the for the Dynacalibrator. Dilution flows will be accurately measured with an SKC-West Accuflow Digital Film Calibrator. The Dynacalibrator effluent flow stream will be routed through a gas-sampling bulb. After complete temperature equilibration of the Dynacalibrator and purging of the gas-sampling bulb, the bulb will be valved off and used as a calibrated sample source to compare with the calibrations obtained with water solutions. Separate calibration runs will be made for each permeation tube.

Blanks

Two types of blanks must be considered, i.e., water blanks and gas blanks. At least one set of each type will be run daily before starting sample analysis. Blanks will be analyzed more frequently if blank contamination is detected or suspected. Water blank analysis will be performed on samples of reboiled deionized water produced in the Sigma 5 Building. Gas blanks will consist of ambient air drawn through the entire sampling train set up at least 1.5 ft above the ground surface, collected, and treated as a sample. Care must be taken in collecting ambient air samples to ensure that the air sample

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is pristine.

Sample Analysis

Samples will be analyzed as soon as possible following their receipt in the laboratory. If some delay in analysis is unavoidable, the sample will be refrigerated until use and then allowed to return to room temperature before analysis. Samples will be withdrawn from the gas-sampling bulb with a gas-tight syringe fitted with a 2-in. sampling needle. In areas with suspected high contamination, an initial sample of 200 μ L will be taken with a 1-mL syringe to avoid accidental overload of the GC. Based on the result, a scale-up to 5 mL may be performed. At least 10% of the samples showing positive detection on the 5-mL or smaller sample should be run in triplicate to provide data for estimating precision. Syringes and gas-sampling bulbs will be vacuum-flushed before reuse.

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